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ABSTRACT

This study is a systematic investigation of female participation in mathematics and science classes in New York City schools. Six major findings reported include: (1) young women's low levels of participation in mathematics and science reflect the overall low levels of participation and reveal lack of attention to excellence in mathematics and science education as well as the limitations of current policy and practices; (2) young women from racial minorities or from low income families face additional barriers to achievement in mathematics and science in that they have lower rates of participation than both their male counterparts and white females; (3) although young women participate at higher rates than young men in beginning mathematics and science courses, their participation rates drop below young men's in advanced courses; (4) the kinds of policies, programs, and practices that encourage female achievement and participation in mathematics and science are often prohibited by basic features of the educational system; (5) despite the fact that young women constitute 48% of the total school population, gender, race, and class differences are maintained through most policies and practices; and (6) recent reform plans omit concrete efforts to ensure equal opportunity and pay only lipservice to those issues. (PK)

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DISCARDED MINDS

How Gender, Race and Class Biases Prevent Young Women From Obtaining an Adequate Math and Science Education in New York City Public Schools

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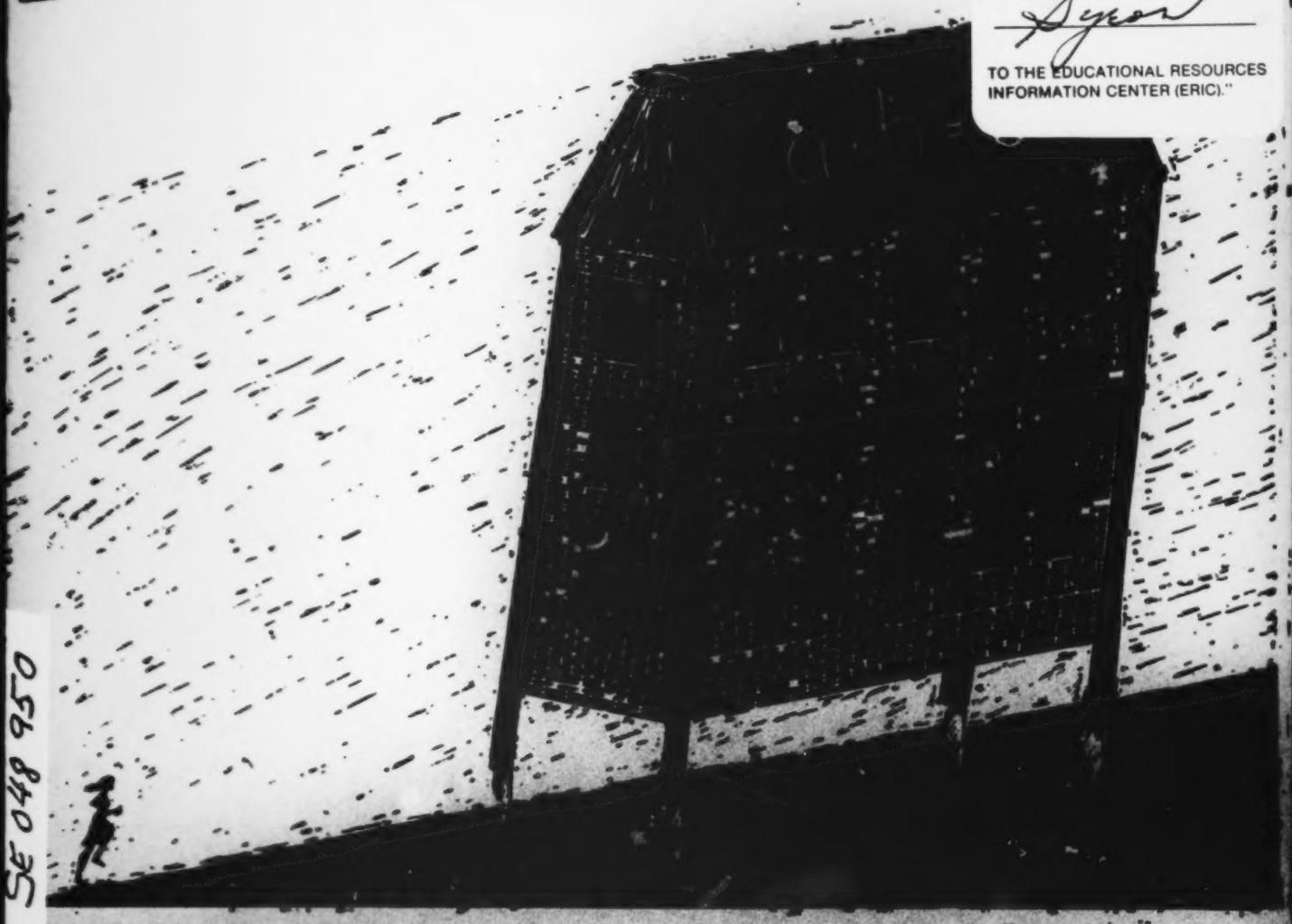

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12 West 37th Street
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Chancellor Quinones granted permission for this study courageously accepting critical review of New York City schools by an "outside" agency. Stan Klein, Les Jacobs and Eva Chang helped shaped the data request and provided most of the statistical data. Principals, teachers, guidance counselors and students were generous with their time and thoughts. Their experiences give life to this study and reveal the policies and practices actually at work in our schools.

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Math, Science and Self-Sufficiency for Young Women

Today, two-thirds of women in the labor force work because they have to. Almost half are single, widowed, divorced or separated. Many support themselves; many support children or their elderly parents as well. Many married women work to supplement their low family incomes. Yet as a result of the low wages, an increasing number of women live in poverty. Indeed, more than a third of families headed by women live below the poverty level.

Judging by the record, increased economic responsibilities almost certainly await the majority of young women coming out of New York City's public school system. However, their prospects for economic self-sufficiency are not so assured. Most of them will eventually find jobs: What they need to be independent are skills which prepare them for better job opportunities and wages adequate enough to support themselves and their families.

In today's technological world, a growing number of jobs demand at least basic math or science proficiency. For example, in a review of 100 jobs, the Occupational Outlook Quarterly lists general math as a requirement for all 100 and Algebra for 69.[1] In return for such skills, employers often pay higher wages. How much are these skills worth? Just one year of high school math translates into an additional $3,000 per year in starting salary, according to researcher Lucy Sells.[2]

Math education alone serves as a critical filter to a wide range of opportunities in our society. It is not only a prerequisite for science study in high school and college (where three years of high school mathematics are required to enroll in most introductory chemistry courses), but math proficiency is also a prerequisite for higher education in many other fields. For example, one research study revealed that over 70% of <u>all</u> majors at two universities require four years of high school math.[3]

There is also evidence that young women who complete high school geometry and algebra score better on entrance exams for civil service, federal and private sector jobs than those who do not take these courses. Not just entry-level jobs, but even many job-training opportunities are open only to applicants with some

mathematics background. One New York City trade union recently added completion of algebra to the list of requirements for its apprenticeship program.[4]

Clearly, the job seeker with adequate math and science skills has a broader range of economic opportunities available to her -- in terms of both employment options and overall earning potential. As her economic opportunities improve, so do her chances for later self-sufficiency.

Economic opportunities depend on many factors including: an economy which offers sufficient numbers of jobs, fair access to jobs, equal pay and adequate preparation. This report focuses on the last -- particularly on math and science preparation in the public schools.

Do New York City schools adequately prepare young women to compete in today's job market with its increasing demand for math and science skills? And if not, how do current policies and practices address this issue?

To answer these questions, FARE first studied course completion data from 54 of the city's 111 high schools as a measure of students' achievement in math and science. (Achievement levels are used as a broad gauge of adequate math and science preparation since increased economic opportunities depend on the completion of basic math and science course requirements.) FARE found that the overall record of female students' math and science course participation in New York City is disturbingly low. More than a third (35%) of the females in the sample never passed Algebra or its equivalent, Sequential Math I.* Less than two-thirds (61.6%) completed biology and less than a quarter (24.5%) completed chemistry.

As poor as female course participation is, however, the participation of male students in math and science courses is only slightly better. The fact is, math and science course participation in New York City is low for all students -- an

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* In New York City students may take Algebra, Geometry and Trigonometry, or Sequential Math I, II and III. Sequential Math is a unified curriculum promulgated by the New York State Department of Education. In Sequential Math, students learn some algebra, geometry and trigonometry at each grade level.

indication of inadequate programs in general. Even so, FARE found dramatic disparities in achievements between students attending predominantly white and predominantly minority schools and between students' achievement at high- and low-income schools.

In all, young women of color or from low-income families fare the worst. Indeed, those young women who already face the greatest barriers to employment and self-sufficiency are also least prepared to compete for available job opportunities.

The Costs of Womens' Exclusion

For white, minority and low-income women, inadequate math and science is first and foremost a bread and butter issue. Women lose the economic edge which high school courses in math and science provide. As noted earlier, just one year of algebra correlates with an additional $3,000 in starting salaries; those 35% of the female students, who had not taken a high school level math course, lose this advantage. Two years of math leads to higher scores on entry level job tests; only 38.2% achieved this level of math preparation. Three years of math is a requirement for many college majors; 25.6% completed these math prerequisites.

Low levels of math and science achievements undermine women's career opportunities. Today, the top five occupations for most female workers are secretary, bookkeeper, sales clerk, cashier and registered nurse.[5] For these five fields, the weekly salary range is $176 to $365. In contrast, women constitute only 5% of the 1,471,000 engineers in this country, 21% of all scientific technicians, and 25% of all life and physical scientists. In the growing field of computer science, females constitute 40% of the workers although the percentage of women in the field drops as salary levels increase.[6] The average weekly salary among these five occupations ranges from $379 to $611. Educational inequities such as inadequate math and science preparation perpetuate sex stereotyping and the system of occupational segregation which has traditionally assigned women, especially women of color, to low-status, low-paying jobs.

Employment trends for minorities in math and science fields indicate the additional obstacles which women of color face in addition to sex bias and discrimination. For example, the New York Times reports that, "...blacks account for only 2.3 percent of all employed scientists and engineers, though they represent 10 percent of the overall American work Force. Hispanics make up 5 percent of all employed persons but account for only 2 percent of all scientists and engineers."[7]

Despite some progress, the number of women working today in nontraditional jobs of any kind remains dishearteningly small. Exclusion of women from these fields extracts a toll on the lives of the younger generation even while they are still in school. With few adult role models who can influence their career aspirations and expectations, talented young women are discouraged from pursuing fields which appear to lack opportunities for them. Without a sense of education leading to opportunity, young women are at risk of dropping out of school. Indeed some research suggests they are at risk of early pregnancy as well. With few other inviting avenues to success, young women are more likely to view traditional alternatives, such as motherhood, as their sole route to self esteem.[8]

Women's exclusion from mathematic and scientific fields also affects the national economy. It seriously limits the nation's creative resources at a time when an expanding pool of qualified U.S. workers is needed to compete in the international marketplace. The shrinking youth population in America has caused national concern about the potential shortage of workers skilled in math and science. The recruitment of nontraditional candidates might bring the fresh talent and new ideas necessary to reshape the American economy, boost its productivity and regain its competitive edge in the worldwide market. Recruitment, however, must begin as early as high school since student enrollment in math and science studies essentially peaks by the twelfth grade and thereafter only declines. Unfortunately, as a result of the continuing low levels of female achievements in high school, women are no more likely to major in math or science in college even though the number of women attending college has increased dramatically over the last ten years.

Although economic concerns are rightly in the forefront, womens' limited participation in math and science fields also creates other, less visible, problems affecting national as well

as individual life. Today, math and science education is a "critical filter" not just to economic opportunity but to social and political participation, too. Speaking of life in the "information age", The National Commission on Excellence in Education cautions that those:

> ....individuals in our society who do not possess the levels of skill, literacy and training essential to this new era will be effectively disenfranchised, not simply from the material rewards that accompany competent performance, but also from the chance to participate fully in our national life. A high level of shared education is essential to a free, democratic society and to the fostering of a common culture, especially in a country that prides itself on pluralism and individual freedom.[9]

Education which fails to meet the need for a scientifically and technologically literate citizenry may exacerbate or create divisions within society. John Slaughter, a former director of the National Science Foundation, warns of "a growing chasm between a small scientific and technological elite and a citizenry ill-informed, indeed uninformed, on issues with a science component."[10] For those many young people who do not go on to college, high school studies are still their only opportunity to master basic scientific principles and mathematical skills.

Finally, a more diverse group of workers may even stimulate beneficial changes in the practice of science itself. As Anne Fausto-Sterling and Lydia English point out: "How might western European science change were it to incorporate non-European perspectives such as those of native America, traditional Africa, traditional Chinese science, and the vision brought to the practice of modern science by western feminists?"[11]

The kind of math and science education young women receive shapes their dreams and aspirations. Later on, it filters economic, political and social opportunities available to them. Although our investigation addresses many issues which affect young men as well, particularly minority and low-income males, FARE maintained its original focus on the adequacy of young womens' education in math and science since the costs of their exclusion are so high -- particularly for poor and minority females -- and the potential benefits of their participation to society so great.

A Standard of Educational Excellence and Equity

Course participation alone is not an absolute measure of "adequate educational preparation" because academic standards especially in math and science vary enormously. Therefore, any measure of adequacy in math and science education must assume a basic standard of educational quality.

Minimum standards in the City's math and science programs are extremely low. Although Algebra, Geometry and Trigonometry are generally considered the standard high school curriculum, New York City schools allow students to fulfill high school math requirements by taking lower level math courses such as Fundamentals of Math or Recordkeeping. Similarly, lower level science courses such as health courses can be taken in lieu of the standard high school science courses. Although other school districts may consider such low level courses as remedial, New York City schools offer an even lower level of noncredit math courses for remedial help.

The basic standard of quality in the city's math and science programs is further eroded by a variety of policies and practices, which are explored in detail later in this report. But even as simple a measure as minimal class time suggests the problem. International comparisons of math and science education place the United States in poor standing. "In many other industrialized nations," the National Commission on Excellence in Education notes, "...the time spent on these subjects, based on class hours, is about three times that spent by even the most science-oriented U.S. students, i.e. those who select four years of science and mathematics in secondary schools."[12] In New York City, the time spent on these subjects is even lower. While New York State recommends 7 class periods per week for science classes and the Board of Education's own Division of Curriculum and Instruction recommends at least 6, the Board only allocates enough money to cover 5 periods per week.

In examining the issue of equity in math and science for young women, we cannot ignore the implications that surface for the improvement of math and science education for all students. Equal educational opportunity is an empty right when the overall quality of the education itself is poor. Therefore, FARE considers equity and excellence inseparable goals.

An excellent school is defined as one "that sets high expectations and goals for all learners, then tries in every way possible to help students reach them."[13]

Equal course participation also cannot be considered an adequate measure of sex equity since providing young women with the same opportunities as young men only begins to address the problems which cause lower female achievements. Although the best predictor of mathematics achievement at age 17 for all students is the number of mathematics courses completed, national studies indicate that equal course preparation alone may not eliminate achievement differences.[14] As noted earlier, occupational segregation and sex stereotyping -- as purveyed by the media and reinforced at home and at school -- go a long way to shape young women's overall attitudes towards their futures. Many realize that they may have to support themselves for some part of their adult lives yet still fail to develop any job or career plans. This lack of vision and direction, in turn, undermines an important source of educational motivation, particularly in math and science studies.

Schools must strive to awaken young women's dreams, lift their self-confidence and develop their talents and abilities. Classroom practices must encourage the full participation and achievement of white, minority and low-income females. Particularly in the areas of math and science, teachers face the challenge of offering realism without killing interest or enthusiasm. As one educator put it, we must "...elucidate the discouragements and obstacles facing those traditionally shut out of scientific, mathematical or technical careers while exposing students to the accomplishments and achievements of pioneers in science."[15]

Ensuring equity in young women's math and science education requires going the extra distance both to ensure equal course participation and to overcome other barriers to their achievements, even those which begin outside of school. Together these efforts form the core of sex equity, an agenda best described in the words of Edith B. Phelps, the former national executive director of the Girls Club of America:

> We have an obligation to those girls who come to us with a dream and to those others whom we must seek out because life holds no dreams. We have an obligation to empower them with experience, knowledge and the courage to know that growth and change are possible; that each of them is never too small to make a difference; that human power is still the energizing force even in a technological age.

Fortunately, New York City's education leaders have broadly accepted this challenge. [16]

FARE hopes that the findings and recommendations of this study will provide useful insight and guidance in solving these problems. In the remainder of this report, the specific challenges faced by the city's education leaders are taken up: Are young women studying math and science? Are there barriers to their full participation? And finally, what steps can educators take to achieve the twin goals of excellence and equity in math and science education -- prerequisites to economic opportunity and self-sufficiency for young women entering today's job market?

Are Young Women Studying Math and Science?

FARE's study of young women's math and science achievements in the city public schools consists of two parts: a statistical analysis of course completion data from 54 of the city's 111 high schools* andanecdotal evidence gathered through site visits to schools and interviews with administrators, staff and students.[17]

The statistical sample of 54 schools represents at least 50% of the academic-comprehensive high schools in each borough and also includes one specialized high school and two vocational high schools. Similar data on alternative schools was unavailable. The data is a retrospective look at the math and science courses taken by the senior classes of 1985 and 1986 prior to their senior year. That is, the data indicates the highest course level attained by students as of their senior year. The course levels in math are Remedial Math/No Credit, Math 9,** Math 10 and Math 11. In science, the course levels are Remedial Science/No Credit, General Science, Biology, Chemistry and Physics. Throughout the report, 1985 and 1986 data are combined. The register for these two classes is 52,116.

A first look at the citywide data on female achievements based on course participation showed relatively small disparities due to gender alone. This was inconsistent with the findings of the National Assessment of Educational Progress which showed significant achievement differences based on gender as well as on race/ethnicity and socioeconomic status. NAEP found that while disparities already existed between the achievements of black and white students at age 13, there was no evidence of sex-based differences at that age. By age 17, however, NAEP found both race and gender differences, although race-related differences remained larger, in fact five times larger than gender-based differences.[18]

The results of the NAEP analysis suggested to us that a closer look at the citywide data might uncover a variety of factors affecting the achievements of young women in math and science. In fact, FARE found that while sex differences in course participation are relatively small, other measures of

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*Charts for all statistical data in this section are presented in Appendix A.

** For example, courses at the Math 9 level include Algebra, Regents Algebra, and Sequential Math I.

achievement reveal significant disparities based on gender. Moreover, young women of color or with low family incomes suffer from disparities in course participation based on race/ethnicity and socioeconomic class.

Citywide Course Participation

Participation in math and science courses for all New York city students is exceedingly low. A full third (35.0%) of the senior classes of '85 and '86 completed only remedial high-school-level math courses by their senior year; only 65% completed Math 9 by their senior year. At the Math 11 level, the percentage of the senior class participating dropped to 27.0%. Grade-to-grade retention rates are fairly consistent though not remarkably high. On average, 64% of the students at each grade level went on to complete a math course at the next level.

In science, course enrollments start out higher with 86.7% completing at least General Science. Still, only 26.5% of the senior class completed the next two levels of science, Biology and Chemistry. Retention rates in science are initially higher than the math rates: an average of 78.9% of the students in the first two levels of science went on to the next level. In the more advanced science courses, Chemistry and Physics, retention rates drop sharply to an average of 38.6%.

In part, these low levels of achievement can be traced back to earlier preparation. The citywide data on mathematics achievements in elementary and middle schools indicates that deficits begin early. Many students enter high school testing below grade level in mathematics. In 1984-85, the most recent year for which figures are available, 48.2% of the eighth graders in New York City tested below grade level and 51.8% tested at or above grade level. These figures show only a slight improvement over previous years.

However, early achievement deficits alone cannot account for our findings of low high-school achievements given the selective group of seniors studied. A comparison of the 1982-83 tenth-grade register and the 1984-85 twelfth-grade register reveals a 47.8% drop in student enrollment among the 54 schools in our sample, reflecting both student dropouts and transfers. Moreover, although it is impossible to determine how many of the

students who left were also among those 48.2% who entered high school scoring below grade level in mathematics, it is probably fair to assume a good deal of overlap.

The seniors in our sample have already accomplished a great deal: they stayed in school. Furthermore, a large majority probably entered high school on or above grade level in mathematics. Still, 35% had not earned any high-school-level math credit by their senior year.

Citywide data suggests two general areas of need which must be addressed to increase math and science course participation. Efforts must focus first, on increasing the initial pool of math candidates and, second, on improving grade-to-grade retention rates, particularly at the advanced science level.

Course Participation by Gender

Differences between female and male course participation in math and science exist but are not large. The greatest difference at any math or science course level between the percentage of males and females participating is 4.4 points. For example, 28.9% of the male seniors completed Chemistry compared to 24.5% of the female seniors. Nonetheless, several indicators suggest more significant sex differences in math and science.

First, although female participation equals or surpasses males at the lower levels, a higher proportion of male students go on to take the more advanced math and science courses. This shift occurs because a higher percentage of females drop out of both math and science studies, reflecting possible differences in interest and/or achievements. Female retention rates are lowest among the advanced science courses, a point raised by several science department chairs during interviews. For example, while 47.1% of the male students who completed Biology went on to take Chemistry, only 39.8% of the female Biology students went on to take Chemistry.

Second, other researchers have found that course participation is not the best measure to gauge possible sex differences in math and science since achievement differences

exist even among males and females who take an equal number of courses. A finer measure, such as achievement test scores, is needed to properly assess possible gender differences.

A preliminary comparison of science achievement test scores undertaken by the New York City Board of Education's Division of Curriculum and Instruction found significant sex differences at grades 5 and 8. Boys outscored girls in four of the five categories on the test: biology, chemistry, physics and earth science. Girls scored higher in the remaining category: process skills, which include safety procedures, graph reading and interpretation. Although the duration of these differences has not been assessed, the NAEP analysis of achievement differences in math and science indicates that early differences enlarge as students advance through school.

Although the data is limited, gender disparities in achievement are evident. Additional information -- such as male-female comparisons of participation in fourth year math and science courses or of achievement test scores -- is needed to clarify the full impact of these gender differences on young women's math and science education.

Course Participation by Race/Ethnicity

Some students of color have shown outstanding achievements in math and science. For example, 82% of the seniors at Brooklyn Technical High School -- a selective special admissions school -- completed an eleventh-grade math course by their senior year; 82.0% had also completed Physics. This strong record of course participation was built by a student population which was predominantly minority (82.0%): 46.3% Black, 23.5% Asian, 12.7% Hispanic, and 0.9% Native American.

Unfortunately, the success of Brooklyn Tech's program -- both in terms of quality and equity -- stands out in stark contrast to the success of programs citywide. In addition to considerably lower citywide achievement rates, dramatic course participation disparities exist between students at predominantly

minority and predominantly white schools.* Almost twice as many students at predominantly minority schools (55.0%) had not passed any high-school-level math courses as students at predominantly white schools (29.1%).

These disparities can, in part, be traced back to the lower schools. A comparison of more recent eighth grade standardized math test scores from ten predominantly white and ten predominantly minority community school districts reveals significant disparities: only 36.4% of the students from predominantly minority districts compared to 62.1% of the students from predominantly white districts scored on or above grade level in math.

In high school, disparities between participation rates at predominantly minority and predominantly white schools exist at every math and science level:

- For every 10 students at predominantly white schools who complete Math 9, there are only 6 students completing Math 9 at predominantly minority schools. A ratio of 10 to 6.
- The ratio of students completing Math 11 is 10 to 3.
- While proportions are nearly equal in lower level science courses, the ratio is 10 to 4 in Chemistry.

Grade-to-grade retention rates are consistently lower in math and science programs at predominantly minority schools than at predominantly white schools. In math programs, an average of 45.1% of the class at each grade level continues on to complete the next level at predominantly minority schools compared to an average of 68.3% at predominantly white schools. In science programs, the average retention rate at predominantly minority schools is 43.0% compared to 60.8% at predominantly white schools.

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*To determine predominantly white and predominantly minority schools, all 52 schools in our sample were ranked on the basis of the number of minority students enrolled in the twelfth grade in 1985 and 1986. The ten schools with the most number of minority students (99.9%) are grouped under the heading "predominantly minority school." The ten schools with the least number of minority students (27.6%) are grouped under the heading "predominantly white schools".

Male and female course participation at predominantly minority schools follows the same pattern of gender differences found in the citywide statistics. Although female students of color complete math and science courses at a higher rate than male students of color initially, the enrollment rates switch by the more advanced course level with a slightly higher percentage of male students continuing on.

Course Participation by Economic Status

Although less dramatic than differences by race/ethnicity, disparities between the math and science course participation rates at schools with lower-income students and schools with higher-income students* exist:

- For every 10 students at higher-income schools completing Math 9, there are 7 students at lower-income schools.
- For Math 11, the ratio is 10 to 5.
- While proportions are again nearly equal in lower level science courses, the ratio is 10 to 5 in Chemistry.

Grade-to-grade retention rates at lower-income schools are consistently lower than at higher-income schools. The average math retention rate at lower-income schools is 54.5% compared to 69.7% at higher-income schools. In science, an average of 46.1% of the students at each level go on to the next level in lower-income schools as compared to 59.5% at higher-income schools.

*To determine low- and high-income schools, the 52 schools in the sample were ranked according to the number of students eligible for the free or reduced lunch program. The ten schools with the highest number of eligible students (65.4%) are grouped under the heading "low-income schools" while the ten schools with the least number of eligible students (14.6%) are grouped under the heading "high-income" schools. Student eligibility for this program is based on family income. A student from a family of four is eligible for a free lunch if the family income is under $14,300 and a reduced price lunch if under $20,350.

Comparison to Findings from Other Studies

Only general comparisons to other research findings are possible since these studies do not share similar designs. However, even general comparisons show that some of our findings on New York City course participation rates follow patterns found in other studies. For example, the National Assessment of Educational Progress found, as FARE found, that race/ethnicity, class and gender all correlate with lower achievements in math and science but that racial/ethnic and socioeconomic factors have a higher correlation to low achievements than gender.

One finding in our study is notably different from other studies, however. Gender differences in New York City course participation rates are much smaller than those found in other studies. This was particularly surprising since recent investigations of sex differences in other areas within New York City public high schools, such as occupational enrollments, found extensive disparities and biases in both vocational and academic high schools.*

A comparison of course participation data from the national, State and City levels suggests one possible explanation for the minimal gender differences in course participation in New York City. Although the accuracy of such a comparison is hampered by different data collection methods**, it broadly suggests that the degree of gender differences correlates with the overall level of course participation. When overall levels of course participation are higher, greater gender differences occur. When overall levels of course participation are low, gender differences are minimal.

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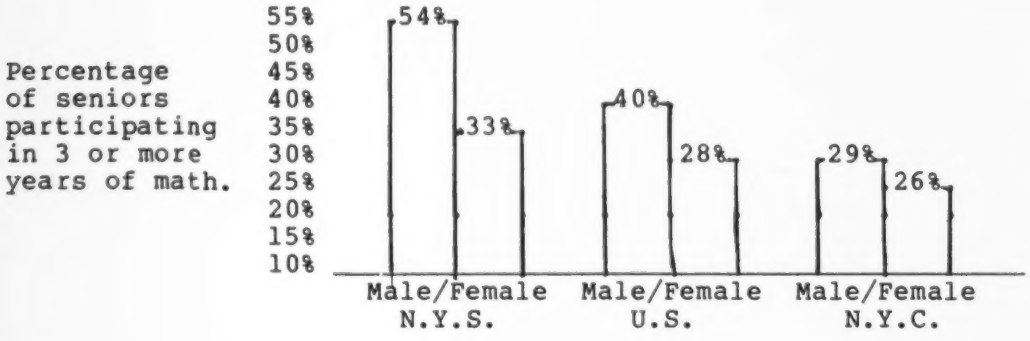
*FARE investigated sex equity in vocational high schools and found extensive sex segregation. See FARE's reports on vocational education: Inch By Inch and Miles To Go.

The only national and New York State study on math and science course participation is a study called **High School and Beyond. Data was collected through a student survey and may be less accurate and/or inflated.

RELATION OF GENDER DIFFERENCES TO OVERALL PARTICIPATION RATES



Thirty-four percent of the nation's seniors completed three or more years of math, as did 44% of the state's seniors and 27% of the city's seniors. The largest gender difference among these three groups is in New York State which has the highest overall rate of participation; the smallest is in New York City which has the lowest overall rate of participation.

The higher the overall rate of course participation, the greater the gender differences. This holds true for science programs as well. This explanation is particularly pertinent given the recent emphasis in New York State on improving math and science education. If reform efforts result in higher rates of course participation, they could also inadvertently result in greater gender disparities unless specific measures are taken to prevent this unwanted side effect.

The Cumulative Effect

Young women are deterred from completing more math and science courses as a result of programs with generally low levels of student participation, racial/ethnic differences, economic differences and, to a lesser extent, gender differences. The particular influence of any single factor is difficult to determine without more comprehensive data since course participation is only a rough gauge of achievement differences and since race and ethnicity often serve as an indirect measure of economic status in American society. But their cumulative effect is clear.

For young women, especially those who are of color or low-income, the combined effect of these factors is inadequate preparation in math and science. In turn, inadequate math and science preparation undermines young women's prospects for adult self-sufficiency, a damaging legacy especially in New York City, where 15.8% of young women became teenage mothers during 1985, and 22.3% of women in 1984 lived in poverty.[19]

Do Policies and Practices Encourage Young Women's Full Participation in Math and Science?

The ideal of American education is to provide an opportunity for all students to achieve their full potential. Yet the disparities in math and science course participation between New York City's male and female students and among racial, ethnic and socioeconomic groups indicate that policies and practices are failing to serve that democratic goal. Young women's lower achievements suggest that the City school system discourages or deters female and low-income students and students of color from pursuing math and science study or careers and thereby limits their chances for future self-sufficiency.

The data on math and science course participation raises many questions: What causes lower participation and achievement rates? Have students been provided with opportunities in math and science studies? Do all students have access to existing opportunities? Are there programs, policies and practices that better serve female, minority and low-income students?

To investigate these issues, FARE visited 11 public high schools and conducted interviews with over 30 staff members and 200 students. In addition, interviews were conducted with representatives from central administrative offices of the Board of Education and representatives from the State Education Department. In the following section, findings from these interviews begin to provide insights into the dimensions of the problem of providing an adequate math and science education for all the City's youth.

Although this investigation focuses on high school policies and practices, it is clear that deficits in math and science begin earlier in student's lives and increase the challenges faced by high school teachers. However, in so far as the Board's promotional policies permit students who are up to two years

below grade level to enter high school, high schools do have an obligation to ensure the achievements of all students, including those with remedial needs.*

The picture of high school programs that emerges in the following section is a mosaic of factors affecting young women's participation in math and science. Diploma requirements, tracking and course sequencing, programming, counseling, curriculum design, testing procedures, special programs and services, remedial opportunities, teacher recruitment, teaching standards, class size and classroom environment all create a labyrinthian system which favors the progress of high achievers and impedes the full development of others.

Although often considered only as educational issues, many are also key equity issues since they have a greater negative impact on young women and, therefore, result indirectly in discrimination. Many of the system's policies and practices preclude educational ingredients which encourage strong and successful math and science participation by young women, especially minority and low-income females. Numerous studies[20] cite the importance of: role models; strong encouragement in math and science studies especially by parents or other significant people in students' lives; and positive career counseling. In addition, educational programs are needed which: promote an understanding of the usefulness and relevance of math and science; encourage general academic success as well as success in early math and science courses; and establish a learning climate which nurtures the development of all young people. But, these critical ingredients are not commonly found in New York City public schools. In addition, some school practices perpetuate stereotypes surrounding math and science by failing to challenge them or by engaging directly in biased and discriminatory actions that limit students' educational development.

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* Analysis of testing data reveal that approximately 50% of the entering high school class in New York City are below grade level in math. Analysis of testing data by race and gender also indicate that equity issues in math and science are of serious concern at the elementary and middle school levels. A representative from a joint UFT and Board of Education academic assistance project for the lower schools, called Dial-a-Teacher, reports that most requests for assistance are in mathematics.

Low citywide participation rates and participation differences based on gender, race, ethnicity and class are by-products of the policies and practices that shape math and science opportunities in New York City's high schools. These policies and practices affect students' education in two fundamental ways: by limiting access to opportunities and by creating and maintaining learning climates which do not foster the achievements of all students.

Graduation Requirements: Two Ways Out of a Maze

A high school diploma is considered a passport to opportunity. It is required for entrance into most institutions of higher education as well as for employment in many fields. Although public schooling culminates in high school graduation, in New York City this singular goal belies the double standards by which students may achieve it. New York City high school graduates earn either one of two diplomas -- a local diploma or a Regents diploma -- which are distinguished among other things by their respective requirements for math and science study.

The availability of different diplomas is the result of New York State's efforts to ensure quality control in education statewide. Public schools, including those in New York City, are under the aegis of the State Board of Regents and the State Education Department (SED). The State sets standards*, which are enforced by State examinations, for both Regents and local high school diplomas. Diploma requirements are also established by the New York City Board of Education. When the City and State diploma requirements are different, the higher requirement takes precedence.

*State standards have recently been revised. However, these new standards did not affect the classes of '85 and '86. This section covers state policies which were in force during the schooling of the class of '85 and '86. Discussion of the impact of the newly revised standards on the math and science education of future classes is presented later in this report.

The credit requirements for both diplomas are similar: Regents and non-Regents students must earn a total of 20 units,* of which a minimum of two must be in math and two in science. In addition, both diplomas require a three-year sequence of courses, called an area of concentration, in math, science, art, music or occupational education. However, here the similarity ends.

Indeed the similarity of credit requirements clouds the dramatic differences between both the level of courses and standard of competency required to fulfill these credits. Although the course work required for either diploma is not directly mandated by the SED, course levels are controlled through state-mandated examinations. For example, all students must pass the Regents Competency Test (RCT) in mathematics in order to graduate. (Students in the classes of '85 and '86 were not required to take an RCT in science.) The RCT is a test of minimum competency in mathematics and covers seventh-, eighth- and ninth-grade material only. It is generally given at the end of the ninth grade although students who fail the test have the opportunity to retake it throughout high school. The RCT is the only State exam in math and science required for students seeking the local diploma.

On the other hand, the State examinations required of Regents diploma students force higher, more rigorous course standards. Regents exams are required in English, Social Studies, and the subject selected for the three-year sequence. If Regents students select math or science for their three-year sequence, firstly, they must take Regents-level courses. Secondly, to earn Regents credit, they must pass standardized state Regents exams at every level. Regents students have some leeway in math and science since they need only take Regents courses and exams if they select one of these subjects as their area of concentration. (The first Regents test in math may be substituted for the RCT.) The lowest level Regents math test is in Regents Algebra or Regents Sequential Math I. The lowest level Regents science test is in Regents Biology.

*One unit is equivalent to the average year long course. Hereafter, all references are made to courses rather than units for the ease of the reader. All mention of courses assume sufficient class time to meet the requirements for one unit.

In comparison with Regents exams, the state's RCT examination allows much lower math and science course requirements. Unfortunately, New York City Board of Education standards fail to raise the State's minimum competency requirements. Indeed, some math department chairs report that students may fulfill the two-year math course requirement with two years of Fundamentals of Math -- a remedial course designed for students who fail Algebra, Sequential Math I or the Regents Competency Test in mathematics. In some schools, students may even fulfill math course requirements by taking two years of Recordkeeping, a course typically offered through the Business Department. Likewise, non-Regents science students may fulfill science course requirements by taking any of a broad range of courses including: non-Regents Biology; lower-level courses such as General Science, Physical Science or Modified Physical Science; or courses from other departments such as Health Education.

The combined effect of the City and State requirements in math and science is tiered math and science programs geared towards either the Regents or local diplomas. Either tier takes the student through the maze that leads to high school graduation, but the level of math and science preparation can differ dramatically. And since the more rigorous Regents diploma is considered highly beneficial for students who intend to go to college, the difference between the diplomas often breaks down along the lines of college-bound students and high-school graduation candidates. It is a system which condones inadequate preparation for some students.

A Lack of Academic Goals and Guidance

Graduation requirements are a poor substitute for students' educational goals and individualized guidance; yet in New York City high schools, they typically take the place of both. This practice is particularly harmful to students because the built-in incentives for math and science study are minimal. Local diploma requirements work only to push students through two low-level math and science courses; Regents standards do provide some incentives for more advanced-level study, although the educational focus concerning Regents students tends to be limited to college readiness. Rarely are either non-Regents or Regents

students' interests, talents or personal goals identified as a basis for programming. When school staff describe how students' courses are selected, they refer only to graduation requirements.

Students confirmed this during interviews. Few had even talked to anyone at school about their personal goals or how those goals should dictate course selection. Even those students who could identify their future goals reported that they did not know what courses to take to achieve them. For example, one student, who is interested in music, wanted to learn sound engineering to have a skill to fall back on. This goal was never discussed with a guidance counselor or grade advisor:

> I don't know what courses I should take so I can learn sound engineering. I've never talked to anyone here about that. I'm just taking what I need to graduate.

Once a student is slotted for the Regents or local diploma, the courses that student is expected to take fall into place. Courses which fall outside these requirements are given little consideration. Education goals are relegated to a limited number of options within which students must fit. The educational process is not tailored to the student; students are tailored to the program.

The concern and interest of some dedicated counselors and teachers is not enough to overcome the system's low priority on providing educational guidance for students. One guidance counselor in New York City serves, on average, over 400 students. As a result, most students have a scheduled visit with a guidance counselor as infrequently as once a year -- and even then, not always for academic reasons. Guidance counselors also complain that their precious time is further limited by enormous amounts of paper work:

> Sometimes kids come in and I have to say "Go talk to someone else, I have to finish this." I don't **want** to do that but I feel like I have to. A lot of the time, I feel like a clerical worker.

As a result, guidance counselors are often forced to attend only to the most pressing issues. Counselors' effectiveness is

further impeded at most schools due to their assignment to students by grade instead of by groups. Rather than follow students throughout high school, most counselors oversee groups of students for only one year at a time.

Course scheduling is often the closest thing to individual assistance in educational goal setting available to students in school. With guidance counselors in short supply, many schools enlist the help of teachers known as grade advisors to schedule students' classes. Some schools simply have a scheduling day: Students attend their regular classes and in each class the teacher programs all students in the class for their next course in that subject area. For example, a math teacher will program each student in the class for her or his next math course. Since no single teacher has an overview of students' personal academic histories, little attention gets paid to planning a program to achieve identified goals or to nurturing students' particular talents and interests.

Several studies indicate that strong educational guidance may be necessary if young women, low-income students and students of color are to participate more fully in math and science courses. In her study of female and minority participation in math and science, Berryman[21] describes three key variables in students' choice of a math or science major in college, all closely tied to educational guidance: early college tracking, strong pre-college preparation in math and science and an awareness of career options in math and science. Young women and students of color tend to be steered away from all three, although for different reasons.

The key for women is the host of factors which motivate young women to pursue more traditional careers shifting their attention away from math and science studies in high school. The key for students of color is parental education: being a second generation college student tends to equalize the choice of a science or mathematics major among white, black, American Indian, Chicano and Puerto Rican students. Berryman postulates that when parents have attended at least some college, they are more likely to assume early on that their children will attend college, more likely to "know about the early training investment" children must make to enter college, and "more likely

to have grown up with wider occupational horizons." Although parental support is invaluable, these are also issues which could be addressed through guidance services.

In New York City where students enter high school with a wide range of abilities and where diploma requirements are low, efforts to assist students in the development of their own educational goals are vital. Without a sense of purpose, students lose a source of motivation which is especially important in math and science both during high school and during the difficult transition to college which some students face.

Test Driven Education: A Misguided System?

Currently, mandated tests have enormous influence on both the curriculum and instruction since these tests are directly tied to diploma requirements. All students must pass the Regents' Competency Tests in Mathematics or a Regents' exam in math in order to graduate. Regents' exams have been even more closely tied to classroom instruction: A student who passes a Regents' course but fails the Regents' test does not receive Regents' credit.* Passing the course is insufficient. Consequently, course syllabi provided by the State Education Department emphasize topics which appear on tests. Teachers also report that their efforts to improve State syllabi are guided by careful review of past Regents' exams.

One fallout of this emphasis on testing is increasing use of test results as a measure of the **quality** of curricula. This effect is obvious in the current debate over the value of a newly-designed and required state math curriculum called Sequential Math. In this curricula, the traditional four year math sequence is restructured and unified. Each course in the sequence covers topics from algebra, geometry, trigonometry and calculus. Ideally, each course builds on material introduced in the previous course.

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*In the Regents' revised standards for secondary education, math instruction is more closely tied to the Regents' Competency Tests as well. A student cannot receive math credit until the Regent's Competency Test is passed.

Although the State Education Department designed the curriculum over the course of several years, its mandated use drew a storm of controversy. Several math chairs criticized the curriculum describing it as superficial and poorly planned. Their concerns are summarized in the comment of one chair, who said:

> Sequential Math gives kids a smattering of each topic. It doesn't allow enough time to really develop students' understanding of the topic. Besides, by the time that topic comes up in the next course, most kids have forgotten what they already learned. It's a terrible curriculum.

Those chairs who are more accepting of the new curriculum quickly emphasize its beneficial effect on students' test scores. As one chair said, "We've been using Sequential Math for several years. I've carefully monitored the effects of the curriculum on students' test scores and they do better. I think it's a good curriculum."

Underlying the controversy about Sequential Math is a debate about the **purpose** of classroom instruction. "Sequential Math may improve students' test scores," one chair rejoined, "but that's not an educational argument." Tests tend to focus on short-term outcomes and, often, a limited form of learning. A student's ability to memorize facts or solve problems does not necessarily imply an understanding of the scientific process, of the usefulness of quantitative assessment, or of the wonder of these subjects.

Benoit Mandelbroit, an innovative mathematician, offers this description of his approach to geometry: "Geometry is sensual, one touches things. I see things before I formulate them." Does preparation for the Regents' Competency Test or Regents' tests in math and science also motivate students to appreciate and continue studying math and science? Will students be exposed to the wonder of mathematics in a test-driven classroom? Will students learn about math and science careers? Will female students be taught that math and science careers are appropriate career options?

At the very least, tests tend to drive these other components of math and science education out of the classroom, an

effect which is often overlooked in otherwise valuable efforts to hold schools accountable. At worst, mandated tests narrow the focus of courses and instruction deterring quality education. Echoing these criticisms, the National Council of Teachers of Mathematics recommends that "stringent standards of both effectiveness and efficiency be applied to the teaching of mathematics" **and** that "the success of mathematics programs and student learning be evaluated by a wider range of measures than conventional testing."[22] Nevertheless, testing is used as the primary measure of school quality in New York City schools while other measures are discounted.

Special Programs: Higher Standards, Limited Access

Math and science course participation is affected by the type of high school a student attends. Many schools offer special programs which are organized around disciplines, such as math or humanities, or around occupational areas, such as journalism or computer programming. The entire curriculum at some high schools, such as vocational high schools, is organized into several special programs. Academic-comprehensive schools often offer a few special programs along with a general high school curriculum. Although the number of these special programs has increased dramatically over the past few years, many were available when the classes of 1985 and 1986 entered high school.

Special programs tend to have specific requirements in addition to diploma requirements. Program requirements vary depending on the type of program. Specialized programs in math and science frequently have stronger math and science course requirements and therefore offer a broader range of math and science courses. By the same token, students enrolled in programs related to math and science, such as Math/Science Institute, Technical Engineering or Medical Science, often take more math and science courses.

On the other hand, enrollment in some programs can have a negative effect on math and science course participation. Programs such as Cosmetology or Business which do not build on math and science skills may only offer enough math and science

courses to allow students to complete their basic credit requirements. Advanced-level courses or other electives are simply not offered. For example, one science chair at a school whose entire curriculum is organized into special programs said,

> There's not much room in the overall school program for science electives. They'd rather put the money and resources elsewhere. It reflects the principal's philosophy of putting our resources into the special programs.

These problems can, in a sense, be considered a tradeoff in exchange for the benefits of offering programs unified around a theme. For example, these programs are able to circumvent some of the problems created by the shortage of guidance counselors. Career infusion becomes almost an automatic feature in the curricula since many teachers have experience in industry or business and can, therefore, easily relate the usefulness of course material to the workplace and career objectives. Indeed, students in these programs were far more able to identify their educational goals and far more enthusiastic about their programs.

This kind of "theme schooling" has other dangers, however. Many occupations have been segregated historically and are often still viewed as more suitable for females or males, whites or people of color. FARE has documented the way in which sex-biased attitudes are transferred to school programs arranged around occupational themes and, thus, results in sex-segregated programs. The register at many of the vocational programs, including many of the technical programs with higher math and science requirements, are 70% or more male.* This problem is also evident in the participation patterns at academic schools whose entire curriculum are organized around special programs. (These schools are called educational option schools.**) Statistics from the five educational option schools in our sample reveal a difference of 8.0 points between the percentages of male and female enrollments at the math 11 level, although this difference is only 3.2 points citywide.

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*See FARE's reports Inch By Inch and Miles To Go.
**The title, Educational Options Schools, refers to a particular admissions formula used by these schools which requires acceptance of students from different levels of ability.

Nevertheless, admission to a special program is the only chance some students have to be in a demanding math and science program. Unfortunately, although student interest in special programs is high, access to them is limited by the small number of programs, by an insufficient number of seats and by selective admissions procedures. For example, of the approximately 92,000 students who expressed an interest in a special program last year by submitting an application, only 33,000 students were placed according to the Office of High School Admissions.

The admissions process which regulates students access to all special programs has been criticized in several recent reports* as unfair and biased on the basis of race/ethnicity, income and sex.

Admissions criteria are set by each school and may involve screening based on tests, review of transcripts including grades and attendance or even racial and ethnic selections based on students' addresses. Prior to application, student access may be limited by inadequate and/or biased guidance. The Board of Education has shown commitment to correcting problems in the admissions process by reviewing existing procedures, banning the use of a few kinds of screening practices and altering the admissions formula for educational options schools. Still, schools independently set their own admissions criteria and have no obligation to show that screening criteria relate to program success.

Special programs open the doors of math and science opportunity for some students, but the limited number of seats and the selective admissions process shut most out.

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*For a more in-depth understanding of the admissions process, see: the Educational Priorities Panel's report Lost in the Labyrinth, Advocates for Children's report Public High Schools, Private Admissions, the Chancellor's University Consultants' report High School Admission and the Improvement of Schooling in addition to FARE's reports on sex equity in occupational programs which cover the admissions process.

Tracking and The Myth of Elective Courses

Student demand for special programs in math and science results, in part, from limited math and science opportunities in academic schools. Some schools offer few courses in math and science preferring to put limited funds elsewhere. With almost 50% of many entering classes performing below grade level in math skills and with low course participation rates, the pool of students eligible to take advanced math and science requirements is limited. Sometimes there are not enough students to fill a class. In fact, some schools offer more-advanced courses only every other year.

In addition, access to existing courses is limited by the curriculum design. Most of the schools studied, including those with special programs, do not really have "elective" courses. According to descriptions by math and science chairs, most courses are offered as part of a "track." Tracking dictates the choice, level and sequence of courses a student is eligible to take. For example, advanced sequences, which lead to a high school diploma endorsed by the New York State Regents, are referred to as Regents courses or the Regents track. An intermediary track, which includes less demanding or non-Regents versions of the same courses, is also available, although not at all schools. In addition, all schools offer lower-level math and science courses in a remedial track for students who are not ready to take ninth-grade math and science courses. Non-credit remedial courses are also offered.

Tracking is so deeply embedded in the school culture that teachers and students seemed genuinely puzzled when asked about elective courses, acting as if they were unaware of any at their schools. The following two statements are typical of the descriptions offered by departmental chairs:

> Students begin with Sequential Math I, II, III. If they do poorly in the first term, they are put into Fundamental and then Consumer Math. After they finish sequential math, they can take 12th year math or Advanced Placement Calculus.
>
> Students who are in the Regents track take Regents Biology, Regents Chemistry and Regents Physics. Students who are in the nonRegents track take Physical Science and Human Biology/Life Science.

As these comments begin to suggest, math and science course participation is circumscribed by the track to which students are assigned. To gain access to a course, students must get in and stay in the track in which the course is offered.

To elect a course outside a track or sequence is virtually impossible. Some department chairs maintain that students can take any course they or their parents desire. In practice, however, the few students who are even aware of this option are discouraged from pursuing it. For example, one Hispanic student had taken Regents Algebra, and although she passed the course, she failed the Regents exam. Subsequently, she was programmed into a lower-level track, even though she was eager to take a Regents Geometry course. Close to tears, she recounted her attempts to get into Regents' Geometry:

> I talked to my math teacher and then I talked to the department chair. But they didn't want me to take Regents geometry. I really like math and I wanted to go on but forget it. I got tired of arguing with them.

Her discussions with her math teacher and the department chair were not successful. Although she might have brought her parents in to help in her efforts, she was too discouraged to continue.

To be fair, some schools do offer electives although only in advanced courses. Better yet, some schools offer a broad range of electives to attract more students into math and science courses. As one science chair described:

> Every possible kid who can be taking a science course, should be. We offer a wide range of electives to accommodate various interests and abilities. We offer many electives which aren't power packed for lower achieving students. We try to offer science courses geared towards students who don't want to attend college. These tend to be related to job opportunities. For example there are entry level jobs now for veterinarian's assistants so we offer an elective in animal care techniques.

Nevertheless, this approach seems to be the rare exception. The general rule is to offer math and science courses as part of rigid tracks.

With such a rigid curricular structure, school efforts to ensure access to higher-level tracks and to promote students' success once they are in higher tracks are doubly important. How do students end up in these different tracks? Who has access to these opportunities? What efforts are made to ensure that the most students possible take higher level courses? And what other effects do the existence of tracks have on students' high school experience, particularly in math and science.

Placement in Tracks: Few Second Chances

Initial placement in tracks occurs no later than the end of the first year of high school, perhaps to accommodate tracks which include three-year course sequences. Placement policies are set by each school and involve a variety of standards and procedures.

Some schools place all students in the same ninth-grade course and use that as a test of their ability. Others place entering students in math and science courses on the basis of their junior-high record. High schools may review standardized test scores, grades, courses completed, attendance or some combination of all of these. Sometimes junior-high guidance counselors offer recommendations.

Even with a review of students' earlier achievements, math and science chairs expect some adjustment in placements during students' first year. Schools report that junior-high records are sometimes incomplete and that course titles and standards are inconsistent, making interpretation of student records difficult.

Standards for placement in math tracks vary. At one school, students must be on grade level in both reading and math in order to be placed in a Regents math course. At another school, every incoming student is placed in Algebra. As a back-up to this more risky approach, the lower-level Fundamentals of Math course syllabus parallels that of the Algebra course for the first term, therefore easing mid-term transfers of students failing Algebra to the lower level course.

The standards for placement in science tracks seem to be broader. One school requires students to be reading above the ninth-grade level to be placed in the Regents track. Another school allows students to take Regents Biology if they are not more than one-and-a-half years below grade level in reading and not more than one year below in math. Another places all incoming students in General Science; then students who receive a grade of 70 or higher are subsequently placed in the Regents track. Another chair said, "In the ninth grade, students take Physical Science. Depending on how well they do, they then take either Regents Biology or General Biology."

Often, standards for placement in math and science tracks seem to reflect the schools concern over the passing rate in math and science courses. To ensure a higher passing rate, some schools emphasize careful and highly-selective screening. Departmental chairs at these schools argue that selective screening is a help to students who might otherwise suffer because they fail a course. Their emphasis is on selecting the appropriate students for courses. Other chairs argue that selective screening only protects the school and denies students a chance to succeed. Their emphasis is on pushing students to try more-challenging courses before tracking students out of them.

After students are placed in a track, they remain in the track unless they fail a course (or fail the Regents exam at the end of Regents course) or, in some cases, choose to drop out of the track. Again, schools respond to course failure in a variety of ways. Typically, when a student fails a course, she also loses her place in the track. In fact, this process seems fairly automatic at most schools. For example, one math chair described program placement like this:

> When students first enter high school, they are placed in math courses on the basis of their junior high math test scores. Students can be placed in Sequential Math I which is always a Regents course. If they can't take Sequential Math, they take Math Fundamentals. They can take Fundamentals for two years or take a course in Applications of Mathematics.

Note that students are not offered a second chance in the Regents course - Sequential Math I. Once the opportunity is lost, it is lost for good. Few real remedial courses are available and few schools offer students a chance to make up a failed course.

According to Webster's dictionary, remedial courses are defined as those designed to bring students up to a higher level of competency. From the descriptions offered by department chairs, it appears that the only truly remedial courses available are the noncredit math courses offered as part of the newly added PREP program, which is designed to bring students skills up to par for participation in the lowest track of math courses.* In some cases Fundamentals of Math is also offered as a remedial course leading to the Regents track. However, at many schools it is offered simply as a course in the lower-level track.

Opportunities to make up failed courses seem limited. In fact, students at one school have to attend summer school to retake a failed course. A few schools offer students an opportunity to make up a failed course on the basis of an assessment of their ability and effort. Ironically, when students exhibit effort and fail, they are demoted to a lower-level track. But when they fail due to a lack of effort, they are given a chance to repeat the course:

> If a kid is placed in Regents Biology and is failing, he would be switched to human biology if the problem is perceived as an academic problem, let's say the kid is making an effort and failing. However, if the kid is failing and has poor attendance, I assume that the kid has not made the effort and I make the student repeat the course.

Most department chairs report that attendance is generally used as a measure of a student's effort.** At one school,

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*The PREP program, instituted in 1983, is characterized by small and separate classes (20-25 students) and more guidance services (one counselor for every 250 students). According to Board of Education Guidelines, student eligibility for this remedial program is based on reading test scores. Once students are assigned to the PREP program, they are placed in PREP math classes, called math lab, on the basis of ability.

**A host of educators and advocacy groups, such as the School Attendance Coalition, have sharply criticized the use of attendance as a sole factor in academic evaluations arguing that academic evaluations should not be used as a disciplinary device.

however, attendance problems are treated as a separate issue and the department does not assume that poor attendance indicates a lack of effort. Instead, the school contacts the student's parents when attendance is low.

All or Nothing, Now or Never: The Problems of a Rigid Curriculum

Due to tracking, gaining access to higher-level courses tends to be an all-or-nothing proposition. A student who is interested in one course but not the entire sequence or who fails to maintain a continuously high level of achievement will be thwarted by the rigid curriculum.

Tracks dictate the sequence of courses to be taken not only within one subject area, such as math, but in all of the different subject areas required for the diploma. To be considered a candidate for a Regents track, students must show that they have the potential to complete all Regents course requirements, that is: four years of English, three years of Social Studies and a three-year sequence in Math, Science, Music, Art or Occupational Education -- and all at the Regents level. A student who could handle Regents math but does poorly in English might not be considered a good candidate for the Regents track, which requires four years of Regents English. Unable to fulfill all the Regents requirements, a student is likely to be placed into the lower-level track simply to ensure that he or she passes enough courses to graduate with a local diploma.

Thus, tracking favors the all-around achiever and penalizes the student whose talents or interests are limited to one or two courses or areas. There is no incentive in the system to accommodate the disparate abilities and interests of the individual. As a result, some able students are discouraged from pursuing higher-level math and science studies.

Access to higher-level tracks also tends to be a now-or-never proposition. Higher-level tracks have an inflexible timeline perhaps due to the three-year course requirements. Only those students who make it into a higher-level track during their first year of high school will have the opportunity to take

higher-level courses. This practice is particularly detrimental in New York City where approximately half of incoming high school students are below grade level in math. Even if a student works hard to catch up, opportunities for late bloomers are limited.

These problems only exacerbate a more fundamental problem of rigid curriculum, which has been raised by other researchers. Attacking the underlying premise of tracking, they argue that the practice of grouping students according to their overall ability does not necessarily benefit high achievers while it harms low achievers:

> Studies show that being isolated in homogeneously defined groups is not more educationally beneficial to students. So-called high ability level students tend to achieve at similar rates regardless of whether they are placed in a classroom of students with mixed abilities or of the same high ability level. On the other hand, low-ability level students perform markedly better in a mixed classroom, while being negatively affected particularly in terms of self-esteem and stigma in a designated low-level classroom. Thus, the tracking system not only contradicts the stated purpose of education, but it fails to justify its reason for existence. It is beneficial to no students, while being harmful to many.[23]

The combination of these factors--grouping students by ability, offering math and science courses in rigid sequences, requiring high achievements in other areas, maintaining a strict cutoff point for entry into tracks and eliminating most or all elective courses--has a powerful effect on the math and science opportunities available to students: It creates a curriculum characterized by limited opportunities and downward mobility.

Although rough on all students, this rigid curriculum takes a heavier toll on some groups of students. For example, it penalizes students who enter high school with poor math skills and, therefore, has a greater impact on students of color since a greater percentage of them enter high school below grade level in math. A rigid curriculum, which demands commitment to the entire sequence rather than particular courses, also excludes those whose commitment is more tentative -- for example, a young woman who is interested in chemistry, but is stymied by her fear of being labeled as "science nut."

Finally, tracking also has a more subtle effect on the school climate by influencing students' self-esteem and promoting social divisions among students. During interviews, students in lower tracks confessed their embarrassment, low self-esteem and sense of failure over and over again. This litany seemed to flow, almost inevitably, from students' descriptions of the lower level of their courses. Clearly, tracks ascribe status upon students, at least in the view of many students. The stigma of tracking goes further since "membership" in a track is widely recognized by other students. Students are generally aware of who is a Regents students and who is not. Furthermore, some schools exacerbate these social divisions by identifying their Regents students, or their top group of Regents students, as the honors class. The stigma of lower tracks undermines many students' academic confidence, another factor which deters students from participating in math and science courses.

Tracking School Services

The grip of tracks on the school climate is reinforced by the tendency of schools to organize other school services around these tracks. Many schools organize recruitment activities around them; some even mimic dual tracks in their provision of guidance services.

In-school recruiting perpetuates tracks. Recruiting is used, almost exclusively, to encourage students who have already completed two years of math or science in the higher level track to continue their study. Department chairs visit classes to conduct special sessions on the usefulness of math and science and the importance of continuing math and science studies. This approach limits the potential usefulness of recruiting in two ways. Firstly, it ignores the potential impact early recruiting might have on encouraging students to work hard in math and science classes. In addition, later recruiting fails to address students' attitudes towards math and science studies and jobs during their formative early years of high school.

Students' attitudes towards math and science, which are typically well-formed by their junior and senior years, can have a critical effect on their education. For example, some students

in advanced tracks have the opportunity to take advanced placement courses. Not only do these courses provide a "jump start" on college coursework and credit, they also allow students to earn college credit without college costs. While many male students view these courses as a wonderful opportunity, female students tend to approach them with trepidation and often refrain from taking them. Female students often reported that they would delay taking these courses until college, a decision which seemed to stem from both their anxiety about the difficulty of these courses and their less tentative career plans.

Recruiting might be less important if guidance were readily available from school counselors. But limited guidance services prevent counselors from assisting students in the development of individualized educational goals. In lieu of academic guidance, diploma requirements, or sometimes college entry requirements, must suffice as goals, although these are clearly inadequate even for high achievers, as the above example shows. In addition, the tendency of some schools to track guidance services results in different services for different student groups.

The most visible symbol of the dual track in guidance counseling is the college advisor. Despite a limited number of guidance counselors, many schools manage to have a college advisor, a valuable service given the high percentage of New York City high school graduates who go on to attend additional schooling. Still, many students could also benefit from the assistance of a job advisor. For example, many recent reports stress the value of programs which relate education to the job market as part of the antidote for dropping out of school. Yet, few schools manage to provide them. One notable exception is a school which has a career advisor and a career center to assist students directly entering the job market after high school.

Less visible, but perhaps more pernicious, is the subtle tracking which occurs at some schools in the provision of regular guidance services. For example, one school with a special honors class designates one guidance counselor for honors students only. This small group of students has a weekly meeting with their guidance counselor written into their schedule. This arrangement allows the counselor to follow their academic work closely and to offer special trips to learn about different colleges and occupations. Meanwhile, the remaining counselors must each serve over 400 students. Consequently, their time is

often limited to emergency situations such as suspensions and truancy. In effect, a dual guidance system is in operation: one track supports high achievers in their academic pursuits; the other track handles emergencies including many non-academic problems. High achievers get academic support; lower achievers get social services.[24]

Perhaps this disparity in the guidance services students receive helps to fuel current debate about the appropriate role schools should take in the provision of non-academic services. At the very least this example makes one clear point: If social services can only be provided by schools at the expense of basic educational services, young people are **not** well-served. All students, and especially lower achievers, need academic support. Trading academic support for social services undermines the very principle underlying school provision of non-academic services: that educators must strive to teach the whole child.

Life in the Classroom: Teaching and Learning in Context*

The opportunity for placement into a high-level track typically occurs once, at the outset of a young woman's high school career. However, once in a high-level track, she has continual opportunities to fail and few or no second chances. Thus, tracking places enormous weight not only on the success of students' first math and science courses, which shapes their opportunities for further study, but also on the success of each subsequent math and science course. With few remedial opportunities, young women's continued participation in a track depends largely upon their success in the classroom year to year.

In many ways, the classroom is a microcosm of the school system in which each of the preceding factors plays a part. Ideally, every day in the classroom should be an opportunity for students to improve their math and science skills. In fact, the classroom environment in City high schools sometimes hampers

*For further details, see a 1982 report by the comptroller of the City of New York, "The State of Science and Math Education in the New York City School System".

learning by failing to address the unique needs of students: weak skills, advanced skills, differences in orientation to learning and/or motivation based on gender, race, ethnicity or class. Likewise, quality teaching is undermined by the very atmosphere in which teachers work.

School policies and practices including diploma requirements, tracking and rigid curricula dictate the kind of math and science opportunities available to high school students, but what affects students' chances for success in math and science once they are in the classroom? The quality of schooling is shaped by a variety of factors. Some are obvious in their effects. Others, such as attitudes and expectations, along with the broader effects of school policies and practices, exert a more subtle, but equally immediate, influence on classroom life. Altogether, these variables create the context for teaching and learning day to day in city schools:

Large class size. Like other departments, math and science departments are plagued by insufficient resources. A key problem, addressed on the "wish list" of every math and science chair, is class size. The issue can be characterized by two salient features: big classes, little attention.

New York City high school classes are enrolled to a maximum size of 34 students. Theoretically, this cap marks the maximum class size; in practice, it has become the standard class size. In contrast, the average class size in alternative schools where more individualized instruction is stressed is 20-25 students.

Generally, department chairs report that classes are too large. With 34 students, teachers find it difficult to structure any individualized instruction or to give extra attention to students who need it -- be it assistance for those in difficulty or additional challenges for advanced students.

Although a hindrance to teaching and learning at any level, large class size is particularly detrimental in entry-level math and science courses since these classes act as the "switch" that sets students on a track for the remainder of their high school careers. Large classes prohibit the kind of special attention many students need to place well in a math or science track or to succeed in individual courses.

Lack of Bilingual Instruction. The lack of attention most student feel is a problem that is only exaggerated among students with limited proficiency in English (LEP). None of the math or science chairs indicated that bilingual math and science classes were available, although many students are clearly in need of these services. During an interview for this study at a school with a large Hispanic population, some young women had to translate for others in the group so that they could participate and yet none of these students are enrolled in bilingual math or science classes. How well can these young women learn in a class taught in English?

According to a 1985 report by the Educational Priorities Panel[25], only 44 high schools offer full bilingual programs. There are only enough bilingual teachers in math and science to serve 24% of the LEP students in science and 18% of those in math.

Test-driven classrooms. The detrimental affect on teaching and learning imposed by large class sizes is enlarged by the school system's undue emphasis on testing. Students' -- and teachers' -- performance is evaluated by tests. By current standards, test outcomes are the sole measure of school quality. Consequently, rather than ensure comprehension or provide individualized instruction, teachers report that they place a high priority in the classroom on covering the material students need for tests.

In this way, tests seem to dictate course content and the pace of the classroom. In restricting themselves to test material, teachers must exclude information about the relevance of subjects to students' lives; the diversity of historical figures, particularly women and people of color; or the opportunities and jobs to which these studies might lead -- that is, the very information that might motivate students to learn. The pace of test-driven classrooms further discourages individualized attention, an important element in learning and in the development of students' self-esteem.

Given these classroom priorities, it is not surprising that students are acutely critical of teachers' efforts to work with them. They seem to feel the direct effects of large class sizes

and the test-driven curriculum reporting that many teachers don't bother to find out if they understand the material before going on. In fact, many students report that they feel lost in class and that they feel pressured not to "hold things up" by asking too many question. Attention does not seem to fall on students in difficulty; as one student pointed out, "Teachers take time to help the smart kids."

This remark contrasts with the following student comment that typifies students' descriptions of a good teacher: "He always goes around and makes sure everyone understands before he goes on to the next thing."

To a great extent, classes become meaningful because of teachers. Students often refer to their math and science classes by the teacher's name rather than by course title. Moreover, their sense of confidence in their own abilities -- an issue especially pertinent to young women in math and science -- is often linked to stories about their teachers. For example, one female student who stopped taking math in high school said, "I've always had a lot of anxiety about math but I had one teacher in the fifth grade who really helped me. I started to feel a lot more confident. But that's slowly worn off."

Tests, and the curricula they promulgate, do not inspire or motivate students to study math and science, but the input of a teacher can. For example, one student attributes her interest in mathematics to a conversation with her math teacher:

> My teacher explained that math trains you to think more clearly. It's like an exercise to develop your brain. And even if you never use proofs or algorithms, you learn how to think more logically.

By limiting discussion of applications, classroom learning geared strictly towards tests fails to develop a sense of education leading to opportunity. Without that perspective, students are less likely to continue math and science study. Indeed, all of the juniors and seniors interviewed who were still taking math and science courses were able to identify some future goal related to math and science, either preparation for college or an occupation.

Some schools attempt to overcome such constraints through special designs for regular courses. For example, one school attempted to address students need for extra assistance by offering a beginning math course over three terms instead of two. Ironically, this measure designed to help students resulted in additional problems. Although this course did not usually have an enrollment predominated by students of color, the three term course did. To this school's credit, the three term course design was dropped and another design tested. In the new design, the course was offered over two terms but for a double period each day. The makeup of the class did not change with this design and the design proved helpful to students. The double period allows one period of instruction and one working period in which the teacher can give individual assistance. The chair explained the theory behind the course as follows:

> Students often say they understand something in class. Then they go home and try their homework and have all sorts of problems. This course gives them time to get started on their homework while in school so that they can get immediate help from their teacher.

This exception stands in stark contrast to most classrooms where overcrowding and the priority on covering test material severely limit opportunities for individualized instruction.

Insufficient supplies, inadequate facilities. In addition to the limits imposed by a test-driven curricula, teachers are also plagued by insufficient supplies and in some cases, inadequate facilities. Both math and science classes lack supplies particularly materials for laboratory courses. Some schools simply do without; others "manufacture" their own supplies. At one school, both the math and science chairs run concession stands selling food between classes in the hall outside their offices to earn funds for their departments. Manufacturing supplies and fundraising take time away from other departmental responsibilities and place a heavy burden on faculty members.

Some schools also have enormous problems with their facilities. One chair commented, "These labs have not appreciably changed in 60 years." Specially-designed laboratories are needed for biology, chemistry and physics. One

of the schools visited has only biology labs and, therefore, cannot offer other laboratory courses including some of the courses newly mandated by the New York State Regents.*

Even when provisions are made for facilities and equipment, problems arise. One school submitted an order for some expensive science equipment to the central office which handles supplies. The central office decided to order a less expensive version of the equipment requested, not realizing that the less expensive item was in fact a different and inappropriate item. Once the school received the equipment and realized the error, the chair attempted to try and return the equipment. This proved to be next to impossible: By the time the equipment was received by the school, the original order had been processed through the prior year's paperwork and the central office was unwilling to reopen the files. Bureaucratic red tape and foul-ups also plague the redesign of facilities. At one school, for example, laboratories had been renovated recently minus important safety features which had been requested originally.

While computers have been provided for high schools through special funding*, their utilization has been problematic. For instance, they have yet to be installed in some schools where electrical rewiring is needed. In other schools, computers have been installed in one room so that all departments can have access to the machines. Although this approach may be advantageous if it ensures broader use, it depends heavily upon successful implementation. Unfortunately, many schools are still in the process of developing schedules for use of the computer room. Furthermore, many chairs oppose this centralized approach because they believe it limits the educational applications of the computers. For example, several science chairs explained that a computer could be very useful as a tool in laboratory classes if it were located in the classroom. A centralized

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*The Regents have recently revised and expanded diploma requirements including more mandated math and science courses. The Regents plan is discussed later in this report.

**During the city's financial crisis, a financial plan was developed under the auspices of the Municipal Assistance Corporation (MAC). The plan was successful enough to produce surplus funds which have been allocated for special purposes in the city, such as the purchase of computers for schools.

location requires students to spend a separate class period on the computer and prevents a more-integrated use of the machines in the classroom. As one chair commented, "Computers are a tool. The whole approach to their use in the school is wrong."

These problems affect the quality of life in classrooms, discouraging both teachers and students. Indeed, a recent report on this issue by the Educational Priorities Panel begins with the following statement: "The lack of adequate, appropriate supplies and equipment is one of the major frustrations faced by New York City public school students and staff. Beyond the direct effect on instruction, the chronic shortages -- their severity and persistence -- are extremely damaging to morale."[26] Especially in science where many educators believe hands-on learning is the greatest hook for students, these problems undermine efforts to encourage student participation. As one chair said, "The best way to motivate kids is to let the material speak for itself."

Letting "material speak for itself" creates problems of another kind, however, particularly when the content of the material perpetuates sexual stereotypes or other discriminatory concepts. Since older written materials tend to be more biased, the lack of supplies at under-funded schools is a serious equity issues. Although the central board reviews materials, schools select their own materials from approved lists. Central approval has been limited and is currently under revision. Moreover, local review for equity issues is virtually nonexistent in many schools. For example, although one chair noted that "All materials are inclusive of men and women," when asked if the department screens textbooks, the chair replied, "We don't screen textbooks regarding equity issues. It's not a priority basically because we haven't thought about it that much."

Finally, insufficient resources affect provision of extra-curricular activities. Notably those schools which have more funds also have activities like math and science clubs. These activities help to draw a wider range of students in to math and science and in some cases make a specific appeal to female and minority students. For example, one school utilized its newspaper to encourage a student to write an article about women in math. In contrast, this story was told by a chair at another school: "We used to have a ham operators club here. We built our own machine. But it was stolen and we didn't have the money to replace it."

With these obstacles in the school environment, it is not surprising that teachers feel discouraged. As one chair put it:

> If anybody tells me they want to teach math -- despite the high salaries they could get outside of education -- because they like teaching and want to work with kids, I'm suspicious. They definitely don't know what it's like to teach here.

Inevitably, large class sizes, mandated curricula, lack of supplies, poor and inadequate facilities, limited funds for special projects and activities, and teacher discouragement combine to exact a high toll on teachers, one that is almost inevitably transmitted to students.

Erosion of the quality of teaching

The lack of credentials and experience of many math and science teachers only adds to the problems created by large classes and rigid curricula. As numerous reports have noted, there is an enormous teacher shortage in New York City. Official shortages exist for math, science, bilingual and elementary teachers.

A recent report on teaching in New York City indicates the dimension of the problem: "In August 1985, just one month before school opened in September, The Board of Education was 4,200 teachers short."[27] As the report goes on to describe, this shortage results in such practices as the use of out-of-license teachers and the use of teachers without regular credentials, referred to as temporary per diem licensed teachers.

According to department chairs, the effect of the teacher shortage in math and science is a slow erosion in the quality of teaching. Chairs note that their staff training efforts must focus on some very fundamental aspects of teaching:

> I focus on training teachers how to motivate students. Often I have to go into the mechanics.... like how to give a lesson on such and such in an organized way. I have to show them how to make learning math fun and how to make it make sense.

The most-qualified teachers tend to teach the higher-level courses. This is due, in part, to the expertise required for teaching in more-advanced courses and, in part, to the commonly held view that teaching more-advanced classes is a more rewarding experience. In any case, the inexperienced, noncredentialed teachers tend to be assigned to the lower-level math and science classes. During interviews, some top-level administrators also said that they suspect that the most qualified math and science teachers eventually end up in the specialized schools and programs, although this suspicion cannot be verified since the needed data is not kept by the Board of Education. Transfer policy allows teachers with seniority to transfer to the school of their choice. Thus, due to the distribution of more experienced teachers, students with poor skills are placed in double jeopardy by teachers with poor skills.

Although part of the job of the department chair is to provide teacher training and supervision, some chairs feel that the demand outweighs their resources. For example, one chair always uses department meetings to provide teacher training. To do so, he must put all other administrative matters into written memo to his staff, a practice he feels he must hide from his principal.

In the long run, relicensing programs or other measures to increase the number of qualified math and science teachers may help to control erosion in the quality of teaching. For example, the Mathematics and Science Recertification Program, which offers free undergraduate courses to Board teachers who wish to study math or science and become eligible to take the licensing exams in these areas, produced 42 newly licensed math teachers and 12 newly licensed science teachers during the 1984-85 school year. Still, this is a slow process and only begins to meet the need for more licensed math and science teachers. 416 of the original math applicants to the relicensing program and 210 of the original science applicants reported that they were currently teaching at least one course in math or science out of license.[28]

Relicensing programs, programs to induce math and science college majors into the teaching profession and ongoing staff development are all vital measures.

Students' determination and dreams

Although the multiple problems that many young people in New York City live with and bring to school are widely acknowledged, school staff still comment on the strong determination and high aspirations of many students. In fact, one chair at a school with special programs in medical science felt that part of his job was to help temper student's aspirations. "A lot of kids come in wanting to be M.D.'s. We have to educate them about other careers. In classes, we discuss what else is available to them in the field - applications and related careers."

Although some students develop interests in math and science independently of school, school experiences influence students a great deal. According to some researchers, early school experiences often plant the seeds of later interests. Others note the number of students interested in math and science can still grow through the high school years. Students' comments suggest that motivation and interest are not simply individually developed; they often develop interactively through experiences of success in math and science, greater awareness of the usefulness of math and science, and better understanding of the job potential which these skills offer.

As in other subjects in the curriculum, initial motivation in math and science seems to stem from the classroom. Students, especially in the ninth and tenth grades, report that a positive sense of themselves as students was crucial in determining the courses that they liked and pursued. Frequently, students describe this in terms of success. For example, when asked about their interest in math and science, students often describe an important moment of accomplishment. Sometimes, this moment occurred in high school, sometimes earlier. For example, one student said, "When I was in junior high, my teacher made me memorize the entire multiplication table in one day...and I did it!" Another student attributed his inspiration to study science to a science teacher: "We dissected frogs in class. I really liked it and so my science teacher used to let me stay after school to dissect other animals. I guess that's when I really became interested in studying Biology."

The usefulness of math and science, especially regarding future work or educational goals, seems to grow in the latter part of high school. All of the students who continued on to take higher-level math and science courses, especially courses beyond those required for a Regents diploma, cited future goals as the basis for their motivation to keep studying math and science. Although responses were mixed, male students were more likely to mention career goals related to math and science while female students were more likely to cite college entry requirements.

Although inner-city youth are often maligned by the media, many are planning for a hopeful future. Often these plans are tied into their education, perhaps because school, more than other area of their life, is a place where they can take some part in determining their future. These aspirations and hopes are as much a part of what young people bring to school as particular needs or problems.

Discriminatory attitudes and low expectations

Teacher-to-student ratios and the level of skill and experience of the faculty have obvious effects on the quality of education in the classroom. However, the influence of teachers on students' classroom experience occurs in subtle ways as well -- through teachers' expectations. When teacher expectations are low or biased, they can undermine students' self-confidence presenting serious obstacles to learning for even the most motivated students. For example, researcher Elizabeth Fennema found that confidence relates to increased math achievements and course selection and is often low among young women. "Even when there are no sex differences in their math performance, girls tend to feel less adequate in math, to have a greater tendency to underestimate their abilities, and to have less confidence in their abilities than do boys."[29]

In New York City, expectations are often low and, sometimes, biased and therefore offer little help in raising young women's low self-confidence. For example, one teacher said, "Maybe 25 out of 4,000 students will end up taking twelfth year math."

When asked if this low percentage (less than 1%) is of concern, the chair replied, "No, I'm not upset about it. Math is an elective." Another teacher said, "If a kid hasn't learned arithmetic by the time he's in high school, he's not going to."

Sometimes teachers justified their low expectations in terms of gender and ethnic stereotypes. For example, one teacher offered this explanation of the lower participation of students of color:

> In science or math, it is exactly right or exactly wrong. And particularly when kids come from undisciplined cultures such as the Hispanic culture which is more easy going....this may sound prejudiced... but all of a sudden to demand exactness is a foreign idea.

Stereotypes do not necessarily disappear even when students are successful. For example, another teacher said:

> Girls get better grades. They're more organized and more studious. But the boys have more power. Guys seem to have more innate mathematical ability. They're the really strong students. They don't just give back A and B. They also give C and D.

As one educator points out: "Teachers are continually making decisions based upon how people behave without any real knowledge of ethnic behaviors beyond those experienced in their own backgrounds. Furthermore, they are as likely to have stereotypic perceptions of a group as are other members of society."[30] The comments of both students and a few teachers make it crystal clear that low expectations and stereotyped views do appear in the day-to-day life of New York city classrooms.

Sometimes, stereotyped attitudes appear in overt ways. A group of students at one high school were quick to comment on the racist behavior of one of their teachers:

> "He always jokes about coming to school. He says, 'I take the F-train to flunky town."
>
> "Yeah, and when we're talking about things, he always talks down about Black people. Like he'll say, 'Look at Patrick Ewing. Some star. Can't even take care of his own child.'"

The students were asked what they did and how they felt when these "discussions" came up in class. One student, who was

extremely confident and in a special advanced program at school, said, "I argue with him. I tell him about the good things Black people have done." However, another less-confident student admitted how badly he felt: "It bothers me and then I can't keep my mind on my work. I never argue with him."

These more obvious examples of discriminatory treatment are only the tip of the iceberg, according to contemporary educational research which is rapidly expanding our understanding of discriminatory behavior. Less overt, even unintentional or unconscious, discriminatory practices are often much more insidious and every bit as problematic. For example, one remedial math teacher consistently engaged boys in public discussion of math problems. Male students called out the steps to take in solving the problem while the teacher wrote their comments on the board. When female students were called on, the teacher approached their desk and engaged in a private discussion on the particular problem. Boys were encouraged to exhibit their math skills and even to risk making a mistake in front of other students; girls were trained to hide both their skills and their mistakes.

Biases and expectations can be transmitted to students in seemingly inconsequential statements as well as behaviors. Why are some students asked if they've passed a test, while others are asked if they did well? Both comments carry a strong message about what's the most that can be expected from a student. One rather self-reflexive teacher recalled the startling experience of discovering his own sex-biased attitudes in the classroom. "I read Simone De Beauvoir's book[31] years ago. Afterwards, I was constantly amazed at the subtle ways in which my own expectations about male and female behavior surfaced in the classroom. Without a doubt, teachers convey gender stereotypes in the classroom."

In their studies of sex differences in classroom interaction, the Sadkers document the powerful effect of such subtle differences in treatment.[32] They found that teachers call on boys much more frequently than girls, encouraging boys to be active learners and girls to be passive learners. Differences in involvement in the learning process can have lasting effects: Students who are active in class are more likely to become high achievers and develop a more positive attitude towards learning.

Although this in-depth level of behavioral research was not possible for this study, even cursory examples indicate the existence of gender-based differences in classroom interaction and the need for further review of gender-, racial-, ethnic- and class- based differences in teacher-student interactions.

A Low Priority on Equity Issues

Weeding out discriminatory practices is a difficult process requiring concerted and long-term efforts. In their research, the Sadkers discovered subtle discrimination even among teachers intent upon creating an equitable classroom:

> We've met teachers who ... show me their non-sexist textbooks and non-sexist bulletin boards. They insist there is equity in their classrooms. Then, I videotape them as they're teaching - and they're amazed. If they hadn't seen themselves at work on film, they'd never have believed that they were treating boys and girls so differently.

Despite the enormous effect that both subtle and overt discrimination have on students' education, equity issues are not a priority in the day-to-day operation of schools. Few chairs incorporate equity issues into the required reviews of new staff. As one chair said, "Even if I found a problem, I wouldn't know what to do about it." Even those that address equitable treatment in teacher evaluations look for only the most superficial and overt signs: "It's not a criteria. But I would notice if something was really wrong...like if a teacher is only calling on girls or only calling on boys."

Lack of attention to equity issues extends into staff development. None of the department chairs had devoted even one staff-training session to the subject of equity nor had they addressed equity during discussions of other topics. Although this lack of attention appeared to be a lack of concern among some chairs; for others, it was a simple oversight. For example, one math chair had recently written a college math textbook which includes a chapter on equity issues in mathematics. Although well-versed in equity issues as a result of this research, he had simply never thought of conducting a staff training session on the topic. At another school, a guidance counselor, who was also attending graduate school, recently completed her dissertation on

equity issues in schools. However, she was unable to work with either the math or science departments given the limited amount of time in and the tremendous demands on her schedule with which to work with other departments in the school.

The absence of equity issues in training and in curricula is due to the place these issues are given in the school system. Equity issues are seen as peripheral to the task of teaching, as "add-on" items, low on the list of priorities. They are not seen as an invaluable prerequisite to quality teaching like an understanding of child development.

In addition, a common strategy for addressing these problems seems to be to deny their very existence, a response which only exacerbates the problem. As one educator points out:

> We are all involved in stereotyping. To hide this from ourselves or to allow public institutions to ignore the phenomenon does not eliminate stereotypes but rather allows them to exist....[33]

One central office, the Office of Equal Opportunity, is responsible for the difficult task of addressing this denial of the importance and existence of equity issues and problems. OEO provides technical assistance on equity issues, including a variety of workshops; its staff of 8 must work with 111 high schools and 32 community school districts. Although OEO does monitor staffing patterns, it does not actively monitor student participation and achievement. In part this is due to a lack of data; data collection at the Board of Education is limited, uncoordinated and underutilized. In part, OEO's limited monitoring and evaluation is due to a lack of clarity concerning the Board's mandate to this office.

The infusion of equity issues throughout the school system is further limited by a lack of school-based personnel responsible for addressing these issues. Although every school must have a Local Equal Opportunity Coordinator (LEOC), these responsibilities are tacked on to a staff person's existing responsibilities. Their effectiveness is also limited by the way the position is defined. LEOCs play a passive role: rather than act as a coordinator of equal opportunity at the local level evaluating programs or conducting equity activities, they serve primarily as a conduit for complaints.

In contrast, several high schools have adopted a successful model: sex equity responsibilities are assigned to a designated coordinator. These schools, which have been investigated and cited by the State Education Department for failure to comply with equity regulations, developed these positions as part of their plan to come into compliance with state regulations. The Sex Equity Coordinators are a half time position and include responsibilities such as providing necessary support services, monitoring the progress of students, or developing lesson plans.

State and Local Reform Efforts: More of the Same?

New York State and City have joined a host of other states and localities in the current wave of school reform. In 1984, the New York State Board of Regents promulgated a plan called the "New York State Board of Regents Action Plan (RAP) to Improve Elementary and Secondary Education Results in New York". The plan was followed by a regulations for its implementation called "New Part 100 of the Commissioner' Regulations". The RAP includes new course requirements, mandated curricula, increased testing and tougher graduation requirements which will be phased in through 1991. Following suit, the Chancellor of New York City's Public Schools issued a long range plan for improvement of the school system and, more recently, formed a commission to develop minimal education standards.

The RAP imposes a panoply of new requirements including increased math and science requirements for both the local and Regents' diplomas. Some individual requirements have little effect on the city's education programs. For example, the state now requires two years of math and two years of science, a requirement already mandated by the New York City Board of Education. In general, however, the plan significantly increases the responsibilities of the City's schools increasing requirements at a time when teachers, space, supplies, equipment and morale are often in short supply.

In addition to more math and science courses, the plan stipulates higher standards for the quality of required math and

science courses. Two requirements control the quality of course for the local diploma: first, the RAP requires the second of the two required math and science courses to be more difficult than the first; and secondly, the plan requires a Regents' Competency Test in science in addition to the RCT in math.

The Regents' Action Plan also increases the disparity between the local diploma and the Regents' diploma by significantly increasing Regents' diploma requirements in math and science. While past Regents' students were only required to take Regents' courses in English, Social Studies and a three-year sequence, the RAP adds Regents' course and testing requirements in math and science. In other words, past Regents' students were only required to take Regents' math or science courses if they chose one of these subjects for their three year sequence. With the RAP, all Regents' students will be required to take two Regents' math courses and two Regents' science courses, a mandate which is likely to increase tracking in New York City schools.

The Regents' Action Plan includes and, to a large extent, is driven by an annual statewide assessment of educational programs called the Comprehensive Assessment Report (CAR) which is a collection and statewide comparison of data about each school. The first Comprehensive Assessment Report was produced in 1985.

In New York City, 394 schools were listed at the bottom of the state CAR list. These schools, which include elementary, middle and high schools, were then required to develop comprehensive school improvement plans. In addition, the New York State Board of Regents created a new position, Deputy State Commissioner of Education for improving the New York City school system, in response to the large number of low-ranking New York City schools.

The CAR includes information from the past three years about the make-up of each school including size, ethnicity and student mobility as well as information about student performance including test results, graduation rates, drop-out rates and attendance rates. However, all of these criteria do not carry equal weight. Only two -- test results and dropout rates -- are used to rank schools. (Testing includes the results of eight standardized tests.)

1. Third grade reading test scores from the PEP test.
2. Third grade math test scores from the PEP test.
3. Sixth grade reading test scores from the PEP test.
4. Sixth grade math test scores from the PEP test.
5. Eighth grade reading test scores.
6. High school scores from the Math RCT.
7. High school scores from the Reading RCT.
8. High school scores from the Writing RCT.
9. Dropout Rates.

Schools that fall into the bottom 10-15% on any of the nine items are identified as needing improvement and must prepare comprehensive school improvement plans.

The standards used for ranking schools in the CAR report are especially notable in two ways: 1) eight of the nine items focus on testing incorporating no other measures of the quality of instruction and 2) they do not include any measures of equity despite strong statements about the importance of equity in the plan. To the extent that the CAR drives school reform, these efforts tend to result in further emphasis on testing, an emphasis which has already been shown to rule out more individualized instruction or classroom innovation. Moreover, a lack of emphasis on equity at a time when diploma requirements are being raised does not bode well. In a system where a past Chancellor admitted that New York City schools practice "triage" -- a wartime medical practice of channeling services towards those judged most likely to benefit[34] -- and where course enrollment figures already show enormous disparities, this lack of attention to equity puts thousands of students who are female, of color and low-income in greater jeopardy.

Reforms initiated by New York City's Chancellor will neither mitigate nor improve the Regents' plan since they tend to reinforce the educational trends embodied in the Regents' Action Plan. For example, preliminary work from the Chancellor's Commission on Minimum Standards indicates similar emphasis on testing, acceptance of minimal standards for the local diploma and therefore acceptance of dual diplomas with vastly different requirements despite the Commission's stated concern about the importance of alternative means of evaluation. New York City's educational leaders also share the Regents' approach to equity: cite equity as a goal but overlook concrete steps to achieve it.

The New York City public school system is the only large city school district in the United States which does not monitor its own performance in providing equitable education by collecting racial and ethnic data. Although efforts to evaluate gender differences are better, data collection does not include regular evaluation of course participation or achievement test scores.

With such enormous attention focused on the Regents' Action Plan, the Comprehensive Assessment Report and testing, it is not surprising that many of the school system's resources are being channeled towards their support. For example, $6,869,760 dollars have been provided through the efforts of the Comptroller of the City of New York for the Division of Curriculum and Instruction's Computer Science/Mathematics/Science Program. At least a quarter of this money is being spent on projects which are explicitly tied to implementation of the Regents' Action Plan according to the program's 1985-86 status report. RAP requirements demand new curricula, new instructional materials and teacher training. Staff development is the largest piece of the program accounting for 40% of the funds.

Funding priorities indicate the Division's strategy for improving math, science and computer science education at the high school level. Support for special programs and for the development of new curriculum needed to implement the RAP are given the highest priority: 53.7% of the high school funds support special programs and 26.1% support curriculum development. The four special programs funded are the High School of Telecommunication Arts and Technology at $365,000, the Manhattan Center for Science and Mathematics at $364,000, the Paul Robeson School for Business and Technology at $125,000 and the Comprehensive Math Science Program (CMSP) at $45,000. (CMSP is designed to attract minority students to the engineering profession in cooperation with area engineering schools.)

While these measures may eventually improve the city's scores in the statewide Comprehensive Assessment Report, they are unlikely to help the many students who enter high school below grade level in math skills. In addition, the new curricula which is designed around mandated tests are likely to reinforce a narrow focus in the classroom.

Excellence or Equity: A False Dichotomy

A common, but erroneous, assumption regarding education is that excellence and equity are incompatible educational standards.[35] Math and science programs in New York City exemplify the disastrous effect of adopting one standard at the expense of the other. On the one hand, Regents tracks are considered a mark of excellence distinguished by their high standards; yet, they result in a rigid curriculum which excludes able students such as slow starters, students in need of more individualized instruction or encouragement. On the other hand, lower tracks, which basically accept all students, suffer from a lack of standards and thus result in inadequate education.

To a large extent, this tension between equity and excellence stems from the predominant use of students' test performance as criteria to evaluate and shape the school system. Standards which focus on student outcomes tend to result in a test-driven curriculum and prohibit greater flexibility in the classroom including attention to equity issues or students with more academic difficulties. The rigidity of standards increase when tied to timelines -- a ninth grade achievement test, a tenth-grade Regents test -- leading to rigid course sequences and tracking.

Ironically, such standards disregard the most fundamental factor driving school and student improvements: the quality of classroom instruction. Current standards, which make student outcomes the sole measure of school quality, show a glaring lack of concern for what must precede such achievements: that is, high standards in the classroom to foster quality teaching and active learning. In effect, our schools have placed the cart before the horse. Consequently, an educational system emerges which is often hostile both to learning and teaching.

Indeed, existing standards, and the resulting curriculum, have a devastating effect on teachers as well as students. Symbolically, they stand as a lack of faith in teachers' ability to teach. In practices, they impose rigid guidelines on teaching. In the words of one math chair:

> If you're not willing to pay to get good teachers, then you need more curriculum rigidity. It's a replacement but a rather poor one.

Although it may be true, as one principal pointed out, that the effectiveness of schools "all boils down to what happens in the classroom", it is also clear that what happens in the classroom is often heavily controlled by school system policies.

Discarded Minds

Statistics on student participation in math and science courses reveal the cumulative effect of the policies and practices which shape math and science education in the city's schools.

It is a system which treats few students well. One third of the classes of 1985 and 1986 -- students motivated enough to stay in school and graduate, students who will probably continue their education -- had not completed even one high school level math course. Even so, disparities based on gender, race/ethnicity and class exist over and above low citywide math and science course participation rates.

It is a system which seems to pull young women along on the basis of their tendency to be more academically-oriented than young men rather than open new vistas or inspire real interest in the pursuit of math and science. Although some young women achieve in math and science despite these obstacles, chairs' reports of young women who drop out of fourth year math and science courses to take typing challenge the success of the city's math and science programs. Why haven't they learned the value of these subjects or gained enough confidence to pursue them? Why does this system allow young women's participation rates to decline as course levels advance and graduation requirements are fulfilled despite the fact that young women initially fare as well or better than young men?

It is a system which tracks young women of color or from low-income families into lesser opportunities and thus lower achievements. Lower levels of achievement already exist by the eighth grade. Students pay the price for inadequate early education in competitive, highly tracked high school programs with very limited remedial services. Even those students who succeed despite these obstacles drop out of math and science

courses more often than their white, higher-income peers. Subtle and overt discrimination, inadequate career education and counseling and limited academic support can undermine the success of even highly-able students.

It is a system which has not taken the necessary steps to ensure that all students learn. Whatever the causes, the results are clear. It is a system which, in effect, discards young minds.

Towards Better Math and Science Education for All New York City Students: Findings and Recommendations

The failure of the city's math and science programs belies the commitment and concern of many individuals. Programs to improve math and science education exist within city schools, colleges and community organizations. Each provides information and, sometimes, successful models for intervention. (For an abbreviated list of these programs, see Appendix B.)

Still, math and science education in our public schools is in need of revitalization. Our research reveals these major findings:

1. **Young womens' low levels of participation in math and science reflect the overall low levels of participation of all students and reveals the Board's lack of attention to excellence in math and science education as well as the limitations of current policies and practices.** Low minimal standards for the content of required courses reveal the system's low expectations for student achievements. Low standards in combination with dual diplomas encourage tracking and other selective practices in the provision of math and science education. In addition, special programs in math and science are limited and often highly selective, a problem that is exacerbated by some admissions policies and practices. Academic high school programs often lack opportunities both for more advanced students and students with weaker skills. Educational opportunities in lower tracks are particularly inadequate to the demands of a highly technical society.

2. **Young women of color or from low-income families face additional barriers to achievement in math and science: they have lower rates of participtaion than both their male counterparts and white females. In addition to high rates of attrition similar to young women in general, young women of color or from low-income families have lower rates of participation even in beginning math and science courses.**

Young women of color are more likely to enter high school below grade level in math skills indicating the need for additional evaluation and improvement of elementary school

programs. In addition, lower achievement levels in elementary and middle schools are often only reinforced by high school policies and practices. Few programs for remedial support, a lack of academic guidance, extensive use of tracking in math and science programs and few math and science electives work to the disadvantage of low achieving students.

Racial and ethnic stereotypes and a lack of attention to the particular needs of young women of color or from low-income families also undermine their full participation and achievement. Information about math and science careers, exposure to women of color in these occupations, information about colleges, college financing and high school preparation for college can encourage the participation of young women of color or from low-income families although these practices are again uncommon in our public schools.

3. **Although young women participate at higher rates than young men in beginning math and science courses, their participation rates drop below young mens' in advanced courses that prepare students for further study in math and science and, later on, math and science careers.** Gender differences in achievement exist as early as elementary school. Although these achievement differences are often masked in course participation data, these differences can, in turn, discourage young women from continuing their math and science studies.

Programs and practices which might alter these patterns are uncommon in the City's public schools. Academic guidance and career counseling -- especially programs which help young women to integrate their future plans for work, marriage and children -- are generally unavailable or limited to college counseling. Young women are not provided with information about math- or science-based jobs and careers or exposed to role models in these fields.

Classroom practices rarely challenge stereotypes about women, math and science and, sometimes, reinforce them. Early education in math and science fails to provide a strong base for later learning. Although young men can sometimes overcome this deficit as a result of the experiences gained through traditional boys' play, young women carry this lack of experience with numbers, physical objects and functions into high school. Without hands-on experience that emphasizes the applications of math and

science, these subjects appear all the more abstract in later study. Practices that tend to offer the additional support some young women need -- such as those which address math anxiety or a lack of experience with physical objects -- are not commonly used in the classroom. In addition, gender biases and stereotypes which often creep into the classroom affect teacher-student interactions and, ultimately, young womens' achievements.

4. **The kinds of policies, programs and practices that encourage minority, low-income and female students' achievement and participation in math and science are often prohibited by basic features of our educational system.** For example, undue emphasis on testing steers instruction towards "teaching to the test" and away from innovative or experimental classroom practices or classtime spent on career awareness, historical role models, applications or exposure to contemporary role models in the world of work. Dual diplomas, tracking, inadequate academic support, limited counseling services, large classes and lack of bilingual services all contribute to achievement differences based on gender, race, ethnicity and class.

Equal opportunity entails equal access and equitable outcomes. Individual differences in educational outcomes reflect differences in students' interests and talents. However, policies, programs and practices which create, maintain or exacerbate achievement differences based on gender, race, ethnicity or class are discriminatory. Yet the Board fails to assess educational outcomes on the basis of gender, race, ethnicity and class to identify and intervene in discriminatory educational programs or designs.

5. **Despite the fact that young women constitute 48% of the total school population, students of color constitute 78%, and low-income students 49%, the Board of Education maintains and often perpetuates gender, racial and class differences through its policies and practices.**[36] The low priority given to ensuring educational equity is revealed in: the lack of clear oversight responsibility for equity evaluation and intervention; the lack of data collected to allow thorough monitoring of, for example, the participation and achievement of young women, female and male students of color and low-income students or staffing patterns; limited internal monitoring; and limited staffing and resources for equity personnel throughout the system.

Without concrete action to prohibit and prevent bias, discrimination and stereotyping in classroom practices, instructional materials, guidance, academic support services and in the general school climate, our school system will continue to maintain and allow inequitable educational programs. In addition, young women, especially young women of color and from low-income families often need additional encouragement such as the positive portrayal of women in textbooks or career materials to counterbalance the legacy of past discrimination.

6. **Recent reform plans promulgated by both the New York State Regents and the New York City Board of Education omit any concrete efforts to ensure equal opportunity and thus pay only lip-service to these critical issues.** A lack of attention to equity in math and science education at a time when changes in programs, policies and practices are rapidly occurring is dangerous. New policies and practices, which unknowingly undermine the participation or achievement of young women, especially young women of color or from low-income families, could be implemented.

RECOMMENDATIONS

Strong and committed leadership is required to address these findings and to marshall support and resources for a concrete plan of action. These recommendations, which include recommendations for their implementation, are given for that purpose. We hope that additional advice will be sought from directors of existing programs and combined with these recommendations in a concerted effort to improve math and science education.

1. To increase opportunities for students to participate in high-quality math and science programs in high school, the Board of Education and the Chancellor should:

   a. seek to lower class sizes in math and science especially in the ninth grade: in addition to the cap

of 34, the Board should mandate a standard class size of 28 students;

b. provide adequate funding to support full math and science course offerings including all required courses and a range of electives, including courses for high and low achievers in math and science;

c. continue to implement the revised high school formula;

d. continue to evaluate the admissions process and move quickly to adopt the recommendations suggested by the University Consultants, Advocates for Children and the Educational Priorities Panel; and

e. revise the admissions process so that qualified, nontraditional applicants are given priority in screened and educational option programs. (This procedure is already used in unscreened programs.)

2. To increase opportunities for academic support and guidance, the Board of Education and the Chancellor should:

a. identify and implement specially designed programs to improve academic support and guidance within the school curriculum and increase opportunities for individualized instruction;

b. set a long-range goal of lowering the guidance counselor to student ratio to 1:300 with designated incremental steps;

c. adopt a case management approach to guidance services to ensure greater service continuity;

d. increase academic supports offered outside the classroom including: expansion of the Dial-a-Teacher program to the high school level, teacher tutoring as well as peer tutoring, and a broader range of extra-curricular activities in math and science which offer students an opportunity to strengthen their math and science skills in a less competitive and less stigmatized environment; and

e. provide funding for guidance counselor resources especially targeted for career education activities such as trips to work sites or colleges.

3. To encourage higher achievement levels in high school math and science, especially to address the gap between high expectations and minimal standards, the Board of Education and the Chancellor should:

   a. establish a long range goal of ensuring that all students graduate from high school having completed at least Algebra or, its equivalent in the integrated math sequence, Sequential Math I, and at least General Science;

   b. develop assessment measures and minimal standards which encourage a wider range of student outcomes in addition to minimal standards or Regents diplomas;

   c. identify and utilize a wider range of school performance measures in addition to standardized testing; and

   d. mandate the redesign of the curriculum for high school math and science courses that fall below Algebra, Sequential Math I or General Science so that these courses are designed to bring students up to the level of skill required to get back into the regular high school curriculum rather than as an alternative track.

4. To ensure that female, minority and low-income students receive adequate and equal early education in math and science, the Board of Education and the Chancellor should:

   a. utilize mandated testing programs to assess equal educational opportunity and outcomes in elementary and middle school programs by analyzing test score results for gender, racial, ethnic and class differences;

b. identify and promulgate model elementary programs in math and science which are designed to ensure both equity and excellence;

c. ensure that the remedial services, mandated for the lower schools in the Regents' Action Plan, are fully implemented and adequate to the needs of students; and

d. ensure that the Comprehensive School Improvement Plans (CSIP) currently being developed in response to the State's comprehensive assessment report should pay special attention to equity issues including exploration of curricula specially designed to promote the interest and motivation of all students, programs designed to address remedial needs throughout the lower grades and staff development on equity issues in elementary and middle schools.

e. improve bilingual services especially in math and science as recommended by Aspira and the Educational Priorities Panel.

5. To ensure that female, minority and low-income students receive adequate and equal education in high school math and science programs, the Board of Education and the Chancellor should:

a. utilize mandated testing programs to assess both equal access and equal outcomes in math and science programs;

b. identify and promulgate model high school math and science programs which seek to ensure both equity and excellence;

c. develop and institute a comprehensive career education program which begins in elementary school and continues throughout high school and which includes information about a variety of fields, exposure to adult role models working in these fields, opportunities for work experience with supportive mentors, guidance on planning for the integration of work and family, information on colleges and college

financing, guidance for appropriate course selections in high school, and early recruiting for advanced course work;

d. mandate weekly provision of career education and academic guidance services scheduled into students' programs; and

e. improve bilingual services especially in math and science as recommended by Aspira and the Educational Priorities Panel.

6. To ensure better coordination between high schools and the world of work, the Board of Education and the Chancellor should fund the creation of high school-based job centers which can coordinate special career education activities, provide up-to-date information about the job market including appropriate education and training, and serve as a liaison to local business and industry, develop a speaker's bureau which includes representatives from different occupational areas, particularly women and people of color, and coordinate work experience opportunities.

7. To ensure more effective staff training and development on equity issues, the Board of Education and the Chancellor should:

   a. coordinate the existing efforts of the Division of Curriculum and Instruction, the Office of Equal Opportunity and the math and science chairs so that staff training on equity issues in math and science is collectively designed and implemented. This program should include:

      - an equity self-evaluation by math and science teachers and program chairs;

      - a series of followup activities and materials -- including additional assessment tools, information about common problems, information about model programs, films and articles -- should be carefully selected and provided to math and

science chairs to support their ongoing staff training efforts; and,

- o special workshops targeted to these issues should be developed by the Office of Equal Opportunity to back up school-based efforts and train math and science chairs;

b. create special teacher assistance teams which are available to work on a short term, intensive basis with schools experiencing difficulty in providingequitable, high-quality math and science programs;

c. mandate the inclusion of equity issues on teacher reviews; and,

d. support continuation of the current process of self-evaluation on equitable guidance in high schools and community school districts and encourage implementation of a full range of followup activities.

8. To ensure educational equity, the Board of Education and the Chancellor should give this issue higher priority by providing sufficient resources and expertise. Specifically, the Board should:

a. create additional positions in the Office of Equal Opportunity like the Sex Equity Coordinator to address racial, ethnic and class equity issues;

b. create an equity specialist position in the Division of Curriculum and Instruction to ensure that equity issues are infused in all curricular materials, special programs and staff training and development efforts;

c. create a position of full time equity coordinators at every high school and in each Community School District to promote the infusion of equity concerns in the academic and social life of schools based on the successful model of using a sex equity coordinator at the vocational high schools cited for violation of Title IX; and,

d. expand the existing sex equity coordinator positions to full time status and increase their responsibilities to cover all equity issues.

9. To ensure a coordinated and thorough effort, FARE recommends that the Board of Education develop and implement a long-range, comprehensive action plan to eliminate inequitable policies and practices and improve math and science education. Although this plan should be systemwide, its focus should be on affecting the climate at the school level, especially in the classroom. Furthermore, to make implementation more feasible, this plan should be closely tied to existing efforts such as the Regents' Action Plan, Comprehensive School Improvement Plans and Voluntary Compliance Plans. This action plan should be developed in conjunction with principals and other key school staff.

10. To ensure implementation of the action plan for equity and excellence in math and science education, the Chancellor should take direct responsibility for overseeing the implementation and monitoring of this plan, including the following activities:

    a. collection of data on student achievement based on testing, course participation and program participation broken down by race, ethnicity, gender and class;

    b. assessment of school-level equity efforts based on the documentation of these activities by school equity coordinators;

    c. provision of a systemic overview of progress in addressing equity issues based on analysis by the Office of Equal Opportunity of all relevant statistical and qualitative data;

    d. development of a program for school equity reviews to be conducted by the Office of Equal Opportunity mandating annual review of those schools scoring low on measures of equitable programs and reviews of other programs on a random basis; and

e. delivery of an annual report from the Chancellor to the Board of Education and the public on progress in creating a more equitable system, with a review of the data and recommendations for further modifications in the systemwide plan for equity infusion.

11. To ensure the most efficient and effective use of resources, the Board of Education and the Chancellor should distribute all funding for math and science education, including special funding streams such as the Comptroller's money, on the basis of the math and science action plan.

12. To encourage the development of quality programs rather than "test-efficient" schools, the New York State Board of Regents' should support the necessary interim steps required to achieve equitable and excellent programs by:

    a. adopting a more gradual timeline for implementation of the Regents' Action Plan in New York City schools with additional intermediate goals and timetables in addition to the existing standards; and

    b. intervening in programs identified as discriminatory and encouraging the replication of identified model programs. (Programs should be reviewed on the basis of an analysis of the data on course participation and student achievement broken down by gender, race, ethnicity and class collected by the City.)

To ensure high-quality math and science programs that are accessible to all students and promote equitable outcomes on the basis of gender, race, and class will require the support of the Mayor, City Council and the citizens of New York City in addition to the efforts of the Board of Education to ensure that funding for the public schools receives high priority in the budget process. We hope that this report will serve as a call to action.

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APPENDIX A: STATISTICAL DATA

To graduate, students are required to earn two years worth of credit in math and two years worth in science. The level of the courses taken is not stipulated unless the student is seeking a Regents diploma instead of a regular diploma. (To earn a Regents diploma, students are required to take Regents level courses which are more academically challenging and which include a Regents final exam.)

Although the level of courses completed bears little relation to graduation requirements, it relates directly to students' eligibility for enrollment in other courses. Most schools use students' math performance as a screening mechanism for enrollment in science courses. Also, in both math and science, lower level courses serve as a screening mechanism for higher level courses.

The data presented here is aggregated according to the highest course level students attained by their senior year. As a result, the data does not reveal the number of courses taken at each level. For example, a student who has only completed Math 9-level courses may have taken more than one course at that level. However, since our primary interest is to evaluate the adequacy of students' educational preparation for adult reponsibilities, the level of coursework attained, rather than the number of courses completed, is the more relevant factor. Course participation rates reveal student advancement in and attrition from math and science programs.

Mathematics participation is presented according to a scale which extends from Math 9, through Math 10, to Math 11 at the most advanced end. In addition to grade level, math courses could also be distinguished by degree of difficulty. However, the data was not available on this fine a scale. Therefore, Math 9, for example, includes Algebra 1, Algebra 2 and Regents' Algebra.

Science participation is presented according to a scale which extends from General Science at the low end, through Biology and Chemistry, to Physics at the most advanced level of the scale. Again, Chemistry, for example, includes the general chemistry course as well as the Regents' level course.

The percentage of students who completed the prerequisite and then went on to the next level -- grade by grade retention rates -- reveals the points of student departure in the math and science programs.

Course participation data broken down by gender was provided by the University Application Processing Center(UAPC) via the High School Division, New York City Public Schools. UAPC data does not include students' race, ethnicity or economic status. To evaluate course participation according to these variables required the use of additional data.

School data, rather than individual data, on race and ethnicity was collected and used to assess course participation by race and ethnicity. Schools were sorted according to the percentage of minority students enrolled. Then, the math and science participation rates for those ten schools with the most minority students and those ten with the least minority students were compared.

Data on students' ethnicity was provided by the N.Y.C. Board of Education's Office of Student Information Services. The ethnic breakdown for the eleventh and twelfth grade classes in the 1984 Pupil Ethnic Census report were used. This method may result in some slight inaccuracies since some of the eleventh grade students may have dropped out or transfered by their senior year.

The Pupil Ethnic Census itself is also probably inaccurate. The census is conducted in classrooms. Teachers identify their students' ethnicity using the following categories: Black, Hispanic, Asian, American Indian and White. Teacher identification is clearly an unreliable method. However, this data was used since it is the only ethnic data available from the Board of Education.

School data, rather than individual data, on students' economic status was collected and used to assess course participation by economic status. Student's eligibility for the free or reduced lunch program was used as an indication of their economic status. Schools were sorted according to the percentage of their students eligible for the free or reduced

lunch program. Then, the math and science participation rates for those ten schools with the greatest number of eligible students was compared to those ten schools with the least number of eligible students.

During the 1986-87 school year, a student from a family of four was eligible for the free or reduced lunch program if the family earned under $20,350. Since the income brackets for both eligible and ineligible students cover such broad ranges, eligibility should be considered only a very general indicator of students' economic status. Therefore, we simply refer to the population of eligible students as lower income and the population of ineligible students as higher income.

Data on the number of students at each high school eligible for the free/reduced lunch program was provided by the N.Y.C. Board of Education's Office of Student Information Services. The number of eligible students in the class of '85 and '86 could not be obtained since the data was not broken down by grade level. Therefore, the percentage of the school's population eligible for free/reduced lunch is based on the average number of students eligible per year between 1982 and 1985.

CHART I

OVERALL ADVANCEMENT OF 1985 and 1986 SENIORS
IN MATH AND SCIENCE PROGRAMS CITYWIDE

Math Courses Completed	# Seniors (N = 52,116)	% of Senior Class
Math 9 or more	33,948	65.1%
Math 10 or more	20,584	39.5%
Math 11 or more	14,083	27.0%

Science Courses Completed	# Seniors (N = 52,116)	% of Senior Class
G.Science or more	45,159	86.7%
Biology or more	32,042	61.5%
Chemistry or more	13,806	26.5%
Physics or more	4,694	9.0%

CHART II

GRADE BY GRADE RETENTION RATES

Math Courses	% of Prior Level	Science Courses	% of Prior Level
Math 9	65.1%	G.Science	86.7%
Math 10	60.6%	Biology	71.0%
Math 11	68.4%	Chemistry	43.1%
		Physics	34.0%

CHART III

ADVANCEMENT OF SENIORS IN MATH AND SCIENCE PROGRAMS
BY GENDER

	Females		Males	
Math Courses Completed	# Seniors (N = 28,927)	% of Senior Class	# Seniors (N = 23,189)	% of Senior Class
Math 9 or more	18,799	65.0%	15,149	65.3%
Math 10 or more	11,043	38.2%	9,541	41.1%
Math 11 or more	7,397	25.6%	6,686	28.8%

	Females		Males	
Science Courses Completed	# Seniors (N = 28,927)	% of Senior Class	# Seniors (N = 23,189)	% of Senior Class
Gen. Sci. or more	25,306	87.5%	19,853	85.6%
Biology or more	17,817	61.6%	14,225	61.3%
Chemistry or more	7,100	24.5%	6,706	28.9%
Physics or more	2,108	7.3%	2,586	11.2%

CHART IV

GRADE BY GRADE RETENTION RATES

	% of Prior Level			% of Prior Level	
Math Courses	Female	Male	Science Courses	Female	Male
Math 9	65.0%	65.3%	Gen.Science	87.5%	85.6%
Math 10	58.7%	63.0%	Biology	70.4%	71.6%
Math 11	67.0%	70.1%	Chemistry	39.8%	47.1%
			Physics	30.0%	38.6%

CHART V

ADVANCEMENT OF SENIORS IN MATH AND SCIENCE PROGRAMS
BY RACE AND ETHNICITY

Math Courses Completed	Predominantly Minority Schools # Seniors (N = 6,776)	% of Senior Class	Predominantly White Schools # Seniors (N = 11,244)	% of Senior Class
Math 9 or more	3,050	45.0%	7,976	70.9%
Math 10 or more	1,038	15.3%	5,169	46.0%
Math 11 or more	584	8.6%	3,575	31.8%

Science Courses Completed	Predominantly Minority Schools # Seniors (N = 6,776)	% of Senior Class	Predominantly White Schools # Seniors (N = 11,244)	% of Senior Class
Gen. Sci. or more	5,703	84.2%	10,039	89.3%
Biology or more	3,123	46.1%	7,537	67.0%
Chemistry or more	773	11.4%	3,313	29.5%
Physics or more	64	0.9%	1,145	10.2%

CHART VI

GRADE BY GRADE RETENTION RATES

Math Courses	.% of Prior Level Pre. Minority Schools	Pre. White Schools
Math 9	45.0%	70.9%
Math 10	34.0%	64.8%
Math 11	56.3%	69.2%

Science Courses	% of Prior Level Pre. Minority Schools	Pre. White Schools
Gen.Science	84.2%	89.3%
Biology	54.8%	75.1%
Chemistry	24.8%	44.0%
Physics	8.3%	34.6%

CHART VII

ADVANCEMENT OF SENIORS IN MATH AND SCIENCE PROGRAMS
BY ECONOMIC STATUS

	Lower Income Schools		Higher Income Schools	
Math Courses Completed	# Seniors (N = 7,824)	% of Senior Class	# Seniors (N = 11,560)	% of Senior Class
Math 9 or more	4,097	52.4%	8,251	71.4%
Math 10 or more	2,257	28.8%	5,290	45.8%
Math 11 or more	1,265	16.2%	3,895	33.7%

	Lower Income Schools		Higher Income Schools	
Science Courses Completed	# Seniors (N = 7,824)	% of Senior Class	# Seniors (N = 11,560)	% of Senior Class
Gen. Sci. or more	6,342	81.1%	10,133	87.7%
Biology or more	4,580	58.5%	7,565	65.4%
Chemistry or more	1,072	13.7%	3,520	30.4%
Physics or more	77	1.0%	1,026	8.9%

CHART VIII

GRADE BY GRADE RETENTION RATES

	% of Prior Level	
Math Courses	Lower Income Schools	Higher Income Schools
Math 9	52.4%	71.4%
Math 10	55.1%	64.1%
Math 11	56.0%	73.6%

	% of Prior Level	
Science Courses	Lower Income Schools	Higher Income Schools
Gen.Science	81.1%	87.7%
Biology	72.2%	74.7%
Chemistry	23.4%	46.5%
Physics	7.7%	29.1%

CHART IX

COMPARISON OF MATH PARTICIPATION RATES
BETWEEN MALES AND FEMALES
BROKEN DOWN BY RACE/ETHNICITY AND ECONOMIC STATUS

Student Groups	Percentage of Student Group Completing: Math 9	Math 11
Male Students at Predominantly White Higher Income Schools	70.4%	31.3%
Female Students at Predominantly White Higher Income Schools	70.0%	28.1%
Female Students at Predominantly White Lower Income Schools	74.2%	35.2%
Female Students at Predominantly Minority Higher Income Schools	47.4%	9.3%
Female Students at Predominantly Minority Lower Income Schools	39.8%	6.3%

CHART X

COMPARISON OF SCIENCE PARTICIPATION RATES
BETWEEN MALES AND FEMALES
BROKEN DOWN BY RACE/ETHNICITY AND ECONOMIC STATUS

Student Groups	Percentage of Student Group Completing: Gen.Science	Chemistry
Male Students at Predominantly White Higher Income Schools	86.5%	30.5%
Female Students at Predominantly White Higher Income Schools	86.6%	27.3%
Female Students at Predominantly White Lower Income Schools	72.5%	29.7%
Female Students at Predominantly Minority Higher Income Schools	85.9%	12.3%
Female Students at Predominantly Minority Lower Income Schools	84.7%	9.0%

Appendix B: Model Math and Science Equity Programs

Over the past several years, an inventory of model programs designed to increase the participation of female and minority students in math and science programs has been developing. Many of these programs cater to average and above-average students rather than gifted students only.

Often, leadership and elbow-grease are more important prerequisites for their implementation than funding since these programs are not expensive. For example, the overal cost per student of one program is only about $30.00. Moreover, many of these programs could be adopted at least in part if resources for the full program are unavailable.

This list of effective programs from around the nation was compiled by Patricia B. Campbell in her article, "What's a Nice Girl Like You Doing in a Math Class?".

o Southeastern Consortium for Minorities in Engineering (SECME), Georgia Institue of Technology, Atlanta. More than 10,000 black girls and boys with aptitude in math and science have been identified as early as grade 6 and encouraged to continue studying math and science. The program also works with teachers to strengthen courses and to expose students to appropriate courses. After participating in SECME programs, 80% of SECME students plan to attend college, whereas only 50% of black high school students nationwide plan to attend college. Overall, SECME students outperform the national average for blacks on the SAT by 140 points.

o Project SEED (Special Elementary Education for the Disadvantaged), Berkeley, California. Under Project SEED, mathematicians and scientists go into elementary schools service disadvantaged children and teach each day. They provide students with knowledge and appreciation of mathematics as they demonstrate effective instructional strategies for teachers. SEED evaluations have found students achieving more than two months' growth in arithmetic for every one month they spend in the program.

o EQUALS, Lawrence Hall of Science, University of California, Berkeley. EQUALS is an inservice training program for elementary and secondary educators. In either 10 or 30 one-hour workshops, educators learn to use materials and activities that increase the participation and achievement in math of girls and minority boys. Evaluation of the program has found that most participants continue to use the materials for ears after attending the inservice training and that "there is indication that increased participation of girls has been associated with EQUALS activity by some teachers in some schools."

o Expanding Your Horizons, Math/Science Network, Mills College, Oakland, California. One day sessions for female students introduce them to careers in math and science, as well as providing hands-on experiences, access to role models, and information about the link between math and careers. Evaluation of the program has found students increasing the number of math, science, and computer courses they plan to take. Follow-ups have shown that students ultimately enrolled in at least as many math courses as they had said they planned to take after being exposed to the workshop.

Several programs, which have been developed locally, are:

o Beginning Science Equitably: Parents and Schools in Partnership, Educational Equity Concepts, New York City. This program includes a four to six week science activity program for parent and their young children and a model for Training Institutes to disseminate the program throughout New York City.

o A Winning Formula, Office of Equal Opportunity, New York City Public Schools. This documentary videotape portrays the lives, interests, studies and hopes of eight young women -- junior and senior high school students in New York City -- who represent various racial and ethnic backgrounds. A program handbook accompanys the video and includes lesson plans and resource lists. The video is used, in conjunction with staff development workshops, to promote interest in math and science among elementary school students.

o African Math Systems, Central Park East through the IMPACT II program, New York City Public Schools. African Math Systems enables fifth- and sixth- grade children to see how mathematical concepts have been developed in a variety of African countries. Through an examination of games, storeis, and patterns in printing and dyeing, the children learn how mathematics develops out of everyday experiences, and how different cultures stimulate the overall development of mathematics.

o Access for Women, N.Y.C. Technical College, New York City. This program which is designed to encourage female particpation in technical careers includes a program for young women in high school called the High School Pre-Technical Program. A special mathematics curriculum designed to reinforce understanding of the applications of mathematics and to avoid competition has been developed and is taught jointly by the Electrical Engineering and Developmental Skills Departments. Coursework is augmented by tutoring, career information and counseling.

o Comprehensive Math/Science Project (CMSP), a joint venture of CMSP and the New York City Board of Education. CMSP functions as a collaborative in New York City with the six locally based engineering colleges and industry, providing resources to support high school project activities both in and outside of the school environment. CMSP is a field based research and development project engaged in creating and testing models of mathematics curricula and instruction in several New York City high schools which promote minority participation in math and science programs.

o <u>The Neuter Computer: Computers for Girls and Boys</u>, Women's Action Alliance, New York City. This book describes how to plan and evaluate a school computer equity program and lists computer equity strategies to increase girls' computer use. These strategies were developed and tested nationwide in schools by the Alliance.